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ABSTRACT

This resource manual is designed for use with tenth grade boys whose main interest lies in the shop and industrial arts areas. The course emphasizes mathematical problems inherent in various trades and industries. The primary objective is to motivate the student to apply, improve, and increase his computational skills. The manual is divided into six chapters: automotive activities, building trade activities, home and finance activities, related applied activities, and computational activities. Each chapter contains a series of activities designed to present a logical development of a particular mathematics application. Each activity is accompanied by a teacher guide which includes objectives, suggested materials and activity procedures. Most activities have drawings included suitable for copying either for overhead projector use or ditto copying for student use. (JG)

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BALTIMORE COUNTY PUBLIC SCHOOLS

APPLIED MATHEMATICS
TENTH GRADE

A Resource Manual

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Towson, Maryland
1968

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FOREWORD

Applied Mathematics-Tenth Grade is a mathematics course, taught by mathematics teachers, which capitalizes on the innumerable practical problems occurring in day-to-day living. This course, which is the culmination of several pilot projects, places great emphasis on the mathematical problems inherent in the various trades and industries. A primary objective is to apply, improve, and increase the computational skills learned in previous grades. Applied Mathematics features a variety of presentations to motivate and maintain interest. Student involvement is stressed through the use of kits, measuring devices, models, and tapes.

This publication is specifically designed for use with tenth grade boys whose main interest lies in the shop and industrial arts areas. It will presume teacher evaluation in terms of student reaction and behavioral responses. The teacher is urged to study carefully the philosophy of the course and the instructions for the use of the manual and text. These are stated in the following sections of the Introduction.

The Board of Education and Superintendent of Schools wish to express their appreciation to the curriculum committee and to all mathematics teachers of Baltimore County whose participation in the pilot programs made possible the development of this curriculum publication. The staff wishes to acknowledge the valuable contributions of those persons, organizations, and industries listed on the following page.

Special commendation is due Mrs. Beatrice V. Hagedorn, Mrs. Barbara S. Parks, and Miss Martha Ann Lynch for their careful and painstaking effort in the production of this manual.

Towson, Maryland
November, 1968

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INTRODUCTION

A. PHILOSOPHY

Education in a free society has a two-fold obligation. First, it must assist each member to realize his full potential. Second, it must enable each member to become an active participant and a positive contributor to that society. It is only through the discharge of these educational obligations that a free society can continue to exist and flourish.

The various subjects in the school curriculum are organized to focus on this goal of the ideal citizen. Of these disciplines, the study of mathematics assumes a prominent role. There is widespread agreement that mathematical literacy and competence is essential for the preservation of our society. The past decade has seen a revitalization of mathematics, spurred on by the advent of Sputnik, the expansion of science, and the forward thrust of industrial technology. This renaissance has been primarily directed toward the production of needed scientists, engineers, and mathematicians. The shortage of these specialists is matched by a corresponding shortage of craftsmen in the skill trades. This dearth of skilled workers is tending to become a serious bottleneck in the service areas, and in the production of consumer goods and defense items.

The shortage of craftsmen in the skill trades provides an unusual opportunity for curriculum designers to enable students who are not talented in academic mathematics to reach their full potential. Many of these students are talented in hand and eye coordination, which are essential in the skill trades. It logically follows that mathematics courses for these students should be designed to capitalize on the numerous applications in the skilled trade and service areas. The mathematics experiences in such a program should borrow heavily from the laboratory approach involving student activity with measuring devices, industrial materials, and business order forms. This "hands on" approach should be a close approximation to the situations these students will meet in their chosen work. Such a design can make mathematics meaningful to students.

Local industrial organizations as well as national organizations in petroleum, steel, lumber, concrete, and others are most anxious and interested in cooperating with school systems in such programs by furnishing materials and consultants.

The mathematics teacher plays a new role in such applied mathematics courses. He becomes a member of a team of industrial arts and vocational specialists. In the past, the shop teacher taught mathematics along with mechanical skills or procedures. However, the emphasis was upon industrial skills. In general, shop teachers have not been trained as mathematics specialists who can detect and diagnose difficulties which students encounter with mathematical concepts and skills. On the other hand, the mathematics teacher with his broad knowledge of mathematical principles and techniques can bring to the area of the skill trades a competency and literacy in applied quantitative problems. Furthermore, the mathematics teacher is afforded a splendid opportunity to answer the question so often asked by students, "What is mathematics good for ?" It is important to emphasize that the course in applied mathematics for the skill trades should not be characterized as "shop mathematics." Rather, the applied mathematics course is a mathematics course, taught by mathematics teachers, emphasizing mathematical concepts, maintaining and developing computational skills, but capitalizing on the numerous and fertile situations in the applied trades.

In summary, such courses in mathematics oriented to applications in the skill trades are a necessary facet in any curriculum design. These courses provide an opportunity for many students to develop their talents to the fullest, and allow them to make a positive contribution to a healthy economy and to an industrial and consumer complex which demands a plentiful supply of skilled craftsmen.

B. USING THE RESOURCE MANUAL

This manual provides a series of activities for use with applied mathematics students in grade ten. Suggestions for using the activities are included. The teacher is urged to read these suggestions carefully since familiarity with the materials included should be of great assistance in determining the best program for students.

The manual is organized around the following applied areas: Automotives, Building Trades, Home and Finance, and Manufacturing. A section of Related Applied Activities contains miscellaneous activities of an applied nature ranging from specific lessons to suggested speakers and apprenticeship information. The final section of the manual is devoted to Computational Activities and contains a thorough collection of drill type exercises in an applied setting.

STUDENT ACTIVITIES

For each student activity a teacher commentary printed on yellow paper is included. This commentary indicates the title of the activity, the behavioral objectives, appropriate background information, necessary materials, and a suggested procedure for implementation. Student work sheets are printed on white paper and immediately follow the teacher commentary. The teacher can reproduce these work sheets by removing the master copy from the manual and making a thermal spirit master. The spirit master can then be used to produce copies for the students. When necessary, thermal transparencies can be made in a similar fashion. Care should be taken to place the master copy back in the manual for use at a later date.

If color is desired it may be added by using colored masters before duplicating.

The student activities section also includes reference to:

1. Kits. These kits are effective devices for use in small groups or with individual students. The teacher is supplied with all the necessary instructions for use of the kits as well as the accompanying work sheets.
2. Tapes. A series of taped "Man on the Job" interviews have been prepared. Suggestions for use of the tapes are included as well as a brief synopsis of the contents of each tape.

ORGANIZATION OF STUDENT ACTIVITIES

As mentioned above, the activities are organized within broad applied areas. However, the order in which these applied areas are discussed is left entirely to the discretion of the teacher. The interests of the class should be a major factor in determining the selection and length of any particular unit. The activities within a given applied area are arranged according to the desired sequence. The teacher should feel free to change the sequence provided it does not alter the logical development of a particular concept. It is not necessary to teach all activities within a given applied area before proceeding to another area. In fact, experience suggests that it might be more desirable to change topics rather frequently.

Special interests and experiences of the teacher should be given prime consideration when organizing and selecting activities. For example, if a teacher has had previous experience in industry or within a trade, he should be sure to capitalize on such experience in the classroom. In any event, there should be no pressure to finish all activities in the manual or to cover the textbook.

USE OF THE TEXTBOOK

The textbook, Applied Mathematics by Johnson and Andris, should be used in conjunction with this manual. Many activities in the manual are keyed directly to the textbook for exercises or background information. The sections of the text devoted to the trade areas should be particularly helpful.

AUTOMOTIVE ACTIVITIES

I. Activity: Reading a Map

II. Objectives: The student should be able to:

A. Locate a city, town or other location on a map by use of the map index and map coordinates

B. Determine road conditions and road types, transportation facilities available, boundaries, land and water areas, populations and seats of government, and points of interest

C. Find the distance between two locations (that are listed) by use of the map's mileage table

III. Background Information:

Every year new records are set in the number of people using our highways and in the number of miles traveled. Yet, of the millions of people using our highways, relatively few can make full use of the excellent maps and charts offered free by the major oil companies. These carefully edited road maps are seldom found in a classroom even though they contain more facts per square inch than most printed matter. This topic has been developed to help increase map reading skills, to demonstrate how the wealth of information on a road map can be put to greater use, and to offer another practical situation in which students must use the fundamental operations for whole numbers.

IV. Materials:

A. Esso road maps (Delaware, Maryland, Virginia, and West Virginia)

B. Student work sheet, "A Line on Maps" (one for each student)

V. Suggested Procedure:

A. Distribute the maps to each student.

B. Direct the students' attention to the map index and aid them in discovering how to locate a city or town. Locate several cities or towns.

C. Direct the students' attention to the map legend.

1. Have the students tell the symbol as various conditions or geographic items are mentioned.

2. As various symbols are given have the students describe what the symbols represent.

D. Direct the students' attention to the map's mileage table. Have the students find the mileage between several locations listed.

E. Explore other facets of the map such as the chart related to principal recreation areas, city maps, and etc.

F. Distribute the work sheet entitled, "A Line on Maps." Have the students answer the questions working individually.

ANSWERS TO "A LINE ON MAPS"

1. a. R-4
   b. Q-6
   c. F-6
   d. R-5
2. Cumberland, Maryland
3. Gettysburg National Military Park
4. Danville, Virginia
5. South
6. Buckingham Appomatton State Park
7. Prince Edward, 2,500 to 5,000
8. No, a section between Frederick, Maryland, and Hagerstown, Maryland, has not been completed.
9. Divided Highway
10. Appalachian Trail
11. No
12. No
13. No

A LINE ON MAPS

1. What are the map coordinates of:
   a. Laurel, Delaware ______________
   b. Bay Quarter, Virginia __________
   c. Crow, West Virginia __________
   d. Fruitland, Maryland __________

2. What county seat has coordinates L-2? ______________

3. What national military park has coordinates 0-2? ______________

4. What is the largest city that has coordinates K-8? ______________

5. The school for U. S. Army Engineers is at Fort Belvoir (0-4). From the center of Washington, D. C. what direction would you travel to visit the fort (north, east, south, or west)? ________

6. From Lynchburg, Virginia, (K-7) what is the closest state forest? ______________________________

7. In what county is Farmville, Virginia, (M-7)? What is the approximate population of Farmville, Virginia? ______________

8. Can you take the new U. S. 70 route west from Baltimore, Maryland, to Hancock, Maryland? ____________

9. According to the legend, what is the classification of state Route 51 north from Uniontown, Pennsylvania? ____________________

10. What is the closest hiking trail from Chambersburg, Pennsylvania, (N-2)? ______________________

11. Can you rent a cabin in Point Lookout State Park in Maryland? _____

12. If you wanted to go boating, would you visit Patapsco State Park in Maryland? ___________

13. Is there a military airport at Ocean City, Maryland? _________

I. Activity: Finding Distances from a Map

II. Objectives: The student should be able to:

  A. Measure to the nearest inch using a scale (ruler)

  B. Change a distance in inches to a distance of miles by use of the map's scale for distance, (1 inch = 15 miles)

  C. Find the distance between two locations by adding the mileage numbers printed along the highways

III. Materials:

  A. Esso road maps (Delaware, Maryland, Virginia and West Virginia)

  B. Student work sheets

    1. "Taking a Trip" (one for each student)

    2. "Trip Chart" (one for each student)

  C. Rulers

IV. Suggested Procedure:

  A. Distribute the materials to each student.

  B. Discuss the map scale and how to change a measurement in inches to miles using the scale 1 inch = 15 miles.

  C. Discuss the mileage numbers printed on the map along the highways.

  D. Do trip 1 from the work sheet entitled, "Taking a Trip" with the class. Use the work sheet entitled, "Trip Chart" following the steps listed.

    1. Find the coordinates of the towns from the map index and record these coordinates on the "Trip Chart" in Column I.

    2. Locate the towns on the map.

    3. Measure the straight line distance between the two locations using a ruler. Record the measurement in Column II on the "Trip Chart." (Measure to the nearest inch.)

4. Change the measurement from inches to miles using 1 inch = 15 miles and record the distance in Column III on the "Trip Chart."

5. Add the numbers along the highways which represent road distances. Record the result in Column IV on the "Trip Chart."

6. Record the mileage difference between the two computed distances (Column III and Column IV) in Column V.

7. Find, when possible, the mileage between the two locations from the map mileage table. Record in Column VI.

8. Find the difference between your computed mileage (Column IV) and the map's listed mileage (Column VI) and record in Column VII.
   Note: In some instances Columns VI and VII must be left empty.

E. Assign the students problems 2, 3, and 4 from the sheet entitled, "Taking a Trip."

F. Allow the class to make-up several problems to work.

G. Save these charts for the next lesson.

TAKING A TRIP

If you are:

1. Taking a trip from Morgantown, West Virginia, to Parkersburg, West Virginia, traveling by way of U. S. 119 south to U. S. 50 then west on U. S. 50.
2. Taking a trip from Dover Delaware, to Salisbury, Maryland, traveling by way of U. S. 13 south.
3. Taking a trip from downtown Baltimore, Maryland, to Gettysburg, Pennsylvania, using U. S. 140.
4. Taking a trip from down town Baltimore, Maryland, to Williamsburg, Virginia. Your travel plans are to take the Baltimore-Washington Expressway to the Washington Beltway. After traveling on the Washington Beltway, you will take U. S. 95 south to Richmond, Virginia. From Richmond, Virginia, take U. S. 64 south to Williamsburg, Virginia.

5. and 6. Class problems.

TRIP CHART

		I	II	III	IV	V	VI	VII
TRIP	Towns	Map Coordinates	Straight Line Distance to the Nearest Inch	Straight Line Distance in Miles 1 Inch = 15 Miles	Highway Distance in Miles -Read Directly From Map	Difference in Miles Between Col. IV & Col. III	Mileage from Map Mileage Table	Difference Between Col. IV & Col. VI
1	Morgantown, W. Va.	J-2						
	Parkersburg, W. Va.	F-3						
2								
3								
4								
5								
6								

I. Activity: The Time and Expense of a Trip

II. Objectives: The student should be able to:

A. Multiply and divide whole numbers

B. Find the time required for a trip when the distance and average rate of speed is known

C. Find the fuel consumed when the rate of consumption and distance of the trip is known

D. Find the total cost of fuel when the price of the fuel and the amount of fuel used is known

III. Materials:

A. Work sheet entitled, "Trip Chart" from the previous lesson

B. Problem sheet entitled, "Trips Take Time and Money"

C. Work sheet entitled, "Trips: Time and Cost"

IV. Procedure:

A. Each student should have the work sheet entitled, "Trip Chart" from the previous lesson.

B. Distribute the problem sheet, "Trips Take Time and Money" and the work sheet, "Trips: Time and Cost."

C. Using the data from Column IC on the "Trip Chart," complete problem 1 from "Trips Take Time and Money" with the class. Record the results in the appropriate columns on the chart, "Trips: Time and Cost."

D. Allow the students to make-up rates of speeds, fuel consumption rates and fuel costs for the problems they made up in the previous lesson.

E. Discuss other costs of a trip such as meals, oil, tolls, lodging, etc., and how some of these expenses can be eliminated with careful planning of a trip.

F. As a culminating activity, have the class plan a trip, selecting the most direct route with the least travel time. Then have a letter written to one of the major oil companies requesting information about the same trip. Compare the class route with that of the oil company.

TRIPS TAKE TIME AND MONEY

1. For the trip from Morgantown, West Virginia, to Parkersburg, West Virginia, you can average 35 miles per hour. Your fuel consumption rate is 1 gal. of gas for every 15 miles traveled. Fuel costs $.32 per gallon.

2. For the trip from Dover, Delaware, to Salisbury, Maryland, you can average 60 miles per hour. Your fuel consumption rate is 1 gallon of gas for every 13 miles traveled. Fuel cost is $.36 per gallon.

3. For the trip from Baltimore, Maryland, to Gettysburg, Pennsylvania, you can average 40 miles per hour. Your car uses 2 gallons of gas to travel 32 miles and the fuel cost is $.31 per gallon.

4. For the trip from Baltimore, Maryland, to Williamsburg, Virginia, you can average 57 miles per hour. Your gas which costs $.36 per gallon, is consumed at a rate of 1 gallon for every 12 miles traveled.

TRIPS: TIME AND COST

TRIP	Towns	Time for the Trip	Fuel Consumption	Cost of Fuel
1	Morgantown, W. Va. Parkersburg, W. Va.			
2				
3				
4				
5				
6				

I. Activity: Tires

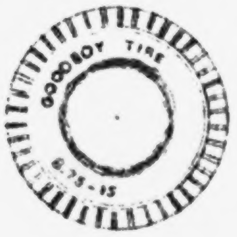
II. Objectives: The student should be able to:

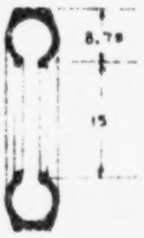
A. Name the parts of the tire to which the tire size corresponds

B. Compute the circumference of a tire from the tire size

III. Background Information:

A.





B. The size of a tire is represented by two numbers, e.g. 8. 75" x 15". The cross section of the tire (as illustrated) measuring 8. 75" is called the diameter shoe. The opening of the tire measuring 15" is called the rim size. The shape of the tire and tread design is referred to by the tire model, e.g. Tiger Paw, Town and Country, Town and Country Wide Oval.

C. The odometer (commonly called speedometer) of an automobile measures the car's speed and the distance traveled. The odometer is connected to the transmission and converts revolutions per minute to miles per hour and miles traveled.

D. A four ply tire has four separate layers of cords in its construction. A tire that is four ply rated has only 2 separate layers of cords in its construction, but these two layers of cords have the same strength as a four ply tire.

V. Materials:

A. Student drill sheets entitled, "A Tire"

B. Student work sheets entitled, "Rolling Along"

C. Optional: Several different tires from the auto shop

D. Optional: Several tire advertisements

VI. Suggested Procedure:

A. Distribute the drill sheets, "A Tire," to each student. Have the students complete the sheet.

B. After correcting the drill, review the concepts of circumference and π. Tell the students to use 3.14 as a value for π.

C. Discuss the measuring principle of the odometer. Ask how an increase in the size of tires on a car would affect the speed and distance registering on an odometer. Ask how tires that are severely worn would affect an odometer.

D. Discuss 4-ply and 4-ply rated tires and radial and conventional tires.

E. Distribute the work sheet entitled, "Rolling Along" and have the students complete the chart and answer the questions.

ANSWERS FOR "A TIRE"

1. 32.50"
2. Rim Size
3. Diameter Shoe
4. Answers will vary
5. C = 3.14 x 32.50

   C = 102.05 inches

ANSWERS FOR "ROLLING ALONG"

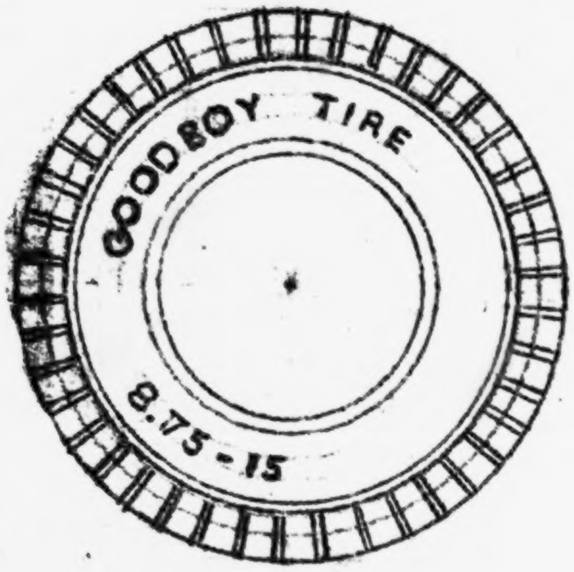
1.

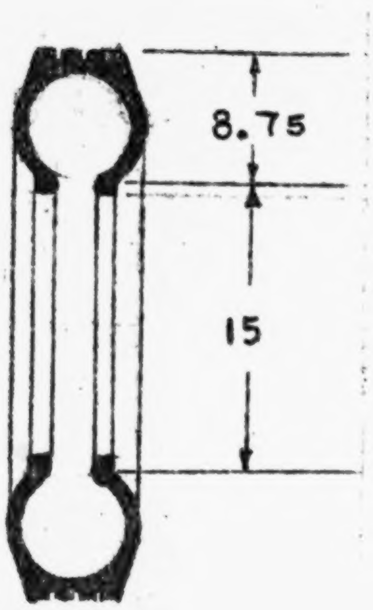
6.50-13	26"	81.64"
7.75-14	29.50"	92.63
8.55-14	31.10"	97.654
9.15-15	33.30"	104.562
6.50-16	29"	91.06"

2. A 6.50-13 tire would appear to be wider because it has the same shoe diameter as a 6.50-16 tire but is 3 inches shorter.

3. The odometer would be registering a greater rate of speed and a greater distance traveled.
4. The odometer would be registering a rate of speed and a distance traveled which would be less than accurate.
5. More, because the car would travel further per wheel rotation.
6. Answers vary.

A TIRE





1. What is the outside diameter of the tire pictured above?
2. What is the "hole," measuring 15" in the tire pictured above, in the tire called?
3. What is the cross section, measuring 8.75" in the picture above, of a tire called?
4. Give some other tire sizes.
5. Find how far the tire, pictured above, travels with one complete turn?

ROLLING ALONG

1. Fill in the outside diameter and circumference of the tires listed.

Tire Size	Outside Diameter	Circumference
6.50-13		
7.75-14		
8.55-14		
9.15-15		
6.50-16		

2. How would a 6.50-13 tire compare in physical appearance to a 6.50-16 tire? Draw a sketch to illustrate your answer.

3. If the odometer is as accurate as possible when new tires are mounted on a car, how would a set of badly worn tires affect the odometer? Why?

4. If your car had 8.25 x 14 tires when you bought it new and you mounted 8.55 x 14 tires on the car, how would this affect the odometer? Why?

5. Refer to Question 4. Would you expect to get more or less mileage from your oversize set of tires? Why?

6. Using the tire size from your family car, determine the distance traveled when the wheels rotate 10 times. How many times must the tire turn to go a mile?

I. Activity: Piston, Connecting Rod, and Crank Shaft

II. Objectives: The student should be able to:

A. Name the parts of a piston and connecting rod assembly

B. Name the part of a crank shaft

C. Describe the assembly and movement of the piston, rings, rod, and crank shaft

D. Apply the rules for subtracting, multiplying, and dividing decimals

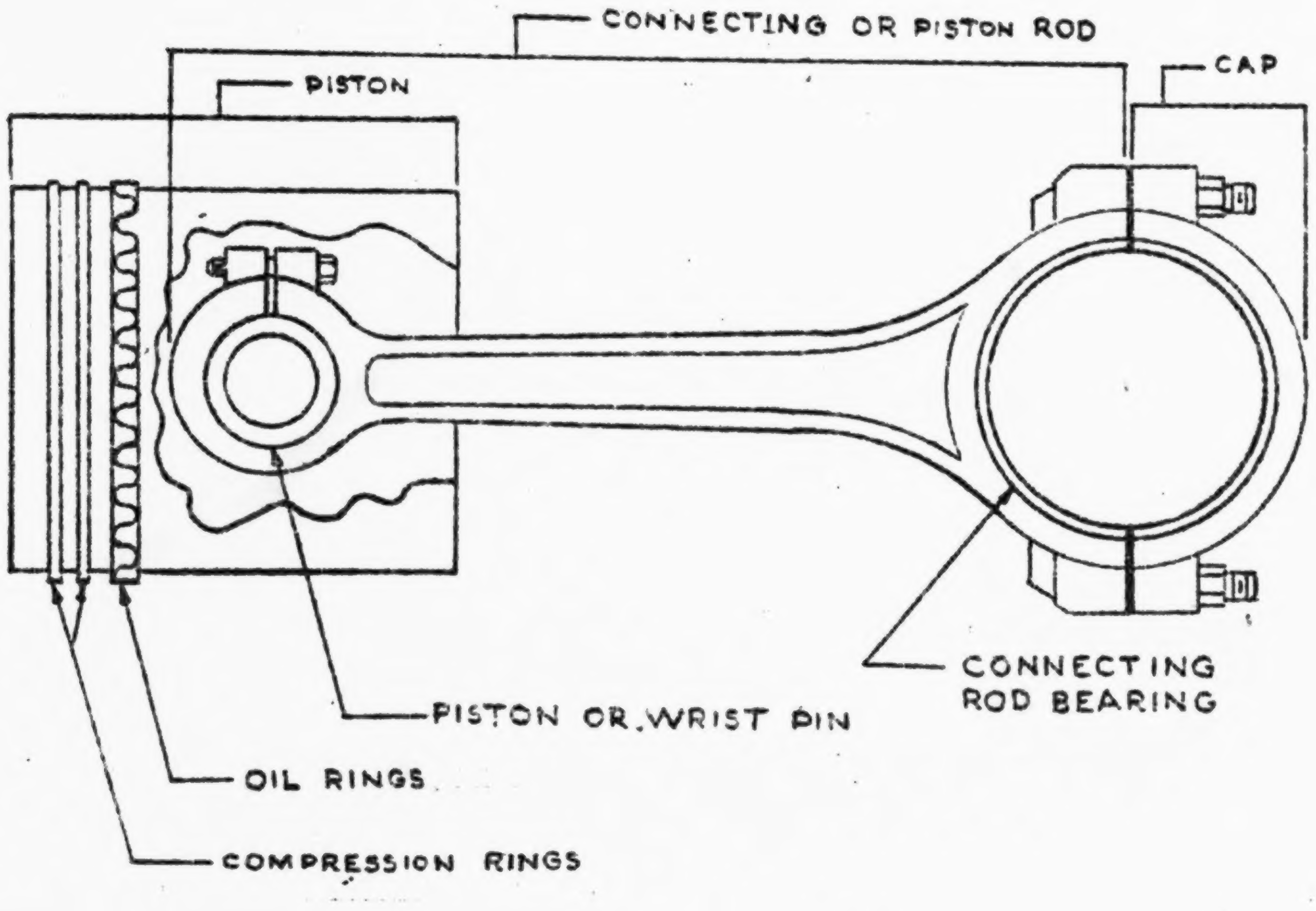
E. Describe the function of the oil and compression rings

F. Define oversize, bore, and clearance

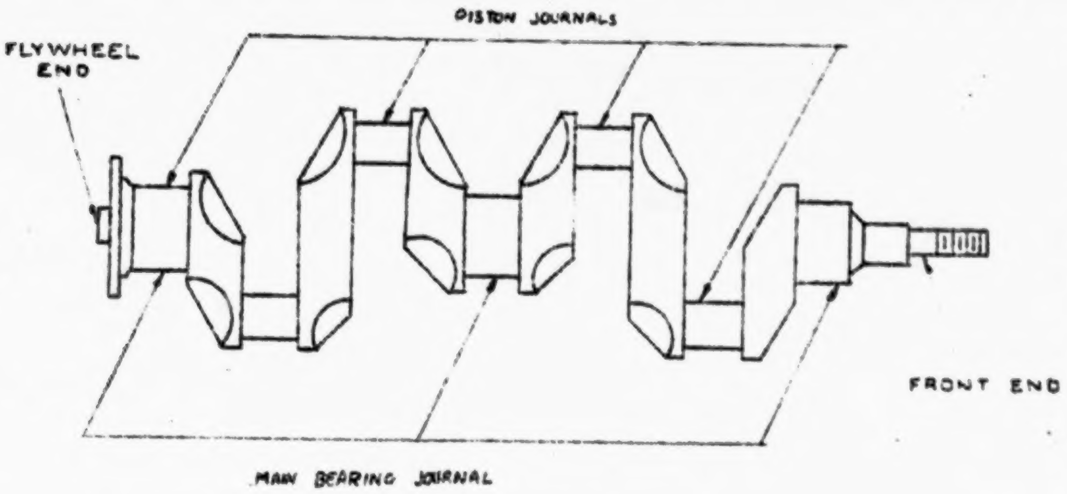
G. Name and identify the diameter of a circle

III. Background Information:

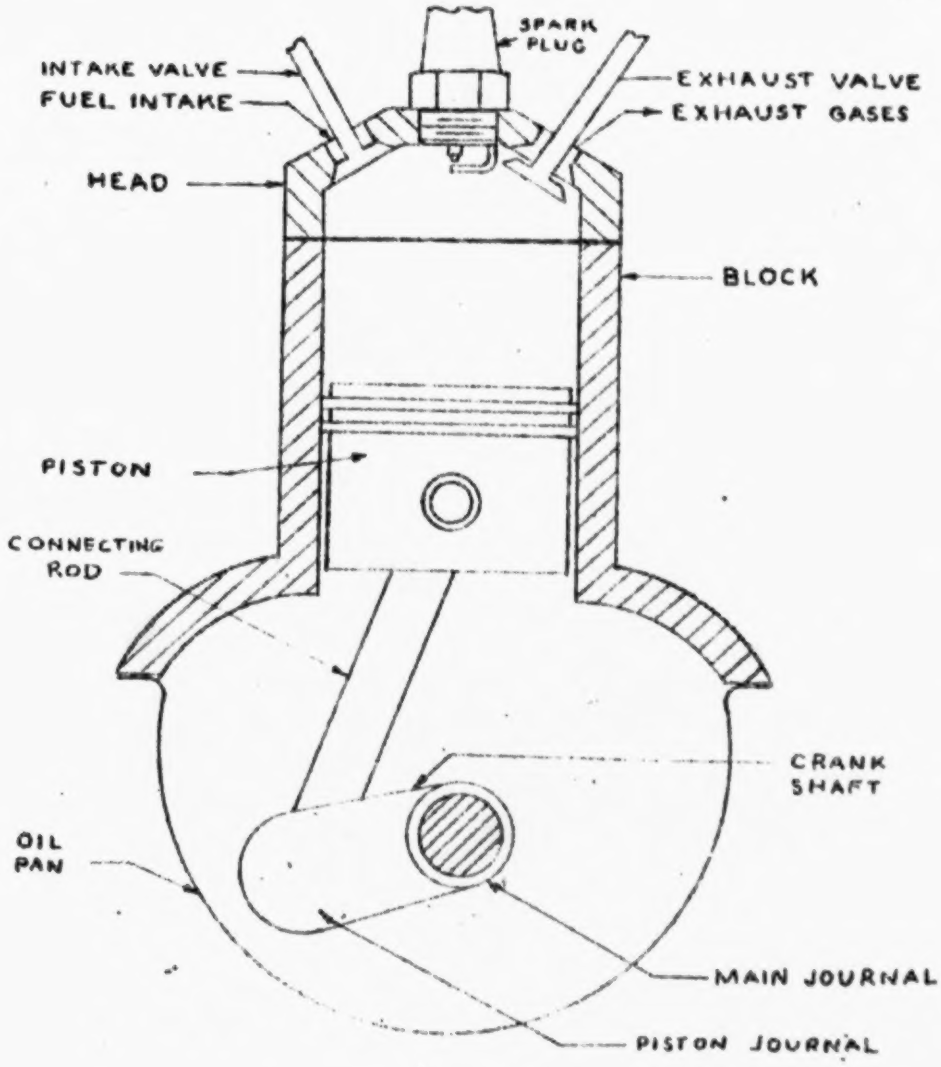
A. Parts of a Three Ring Piston


CONNECTING OR PISTON ROD
PISTON
CAP
CONNECTING ROD BEARING
PISTON OR WRIST PIN
OIL RINGS
COMPRESSION RINGS

B. Crank Shaft for a Four Cylinder Engine


PISTON JOURNALS
FLYWHEEL END
FRONT END
MAIN BEARING JOURNAL

C. A Simplified Front Cutaway View of a Combustible Engine Cylinder


SPARK PLUG
INTAKE VALVE
FUEL INTAKE
EXHAUST VALVE
EXHAUST GASES
HEAD
BLOCK
PISTON
CONNECTING ROD
CRANK SHAFT
OIL PAN
MAIN JOURNAL
PISTON JOURNAL

D. Definitions

1. Cylinder--the round hole in which the piston slides up and down
2. Crank throw--the distance from the center of the main journal to the center of the piston journal (i.e. the radius of the circular path through which the piston journal travels)
3. Clearance--as used in connection with parts having a circular section, refers to the difference between the diameter of the parts being fitted together
4. Compression rings--rings used to keep the cylinder air tight by filling in the clearance space
5. Oil rings-- rings used to wipe the oil from the sides of the cylinder
6. Oversize--this term is used in connection with parts having a circular section, such as pistons, piston pins or wrist pins; refers to an increase in the diameter of the part from the original or standard size (i.e. an engine can have oversize pistons, etc.)
7. Bore--the diameter of the cylinder in which the piston travels

E. Most pistons are either three ring (two compressions and one oil) or four ring (two compression and two oil). The piston is connected to the connecting rod by the wrist pin. The connecting rod is then attached with the connecting rod bearing, to a piston journal on the crank shaft. The crank shaft is then attached to the engine block by the main bearing journals. Though heavy and awkward, the crank shaft must be precisely balanced since it rotates at a very high rate of speed. Balancing cuts can easily be seen on the crank shaft.

F. The piston is forced downward as a result of the fuel igniting at the top of the cylinder. The downward motion of the piston turns the crank shaft.

IV. Materials:

A. Drill sheet entitled, "A Four Ring Piston"

B. Transparencies entitled:

"Parts of a Three Ring Piston"
"Crank Shaft for a Four Cylinder Engine"
"A Simplified Front Cut-A-Way View of a Combustible Engine Cylinder"

C. Four student work sheets entitled:

"Parts of a Three Ring Piston"
"Crank Shaft for a Four Cylinder Engine"
"A Simplified Front Cut-A-Way View of a Combustible Engine Cylinder"
Pistons and Bore"

D. A piston, piston rod assembly, rings and crank shaft obtained from the auto shop

V. Suggested Procedure:

A. Distribute the sheet entitled, "A Four Ring Piston." Have the students give the missing dimensions.

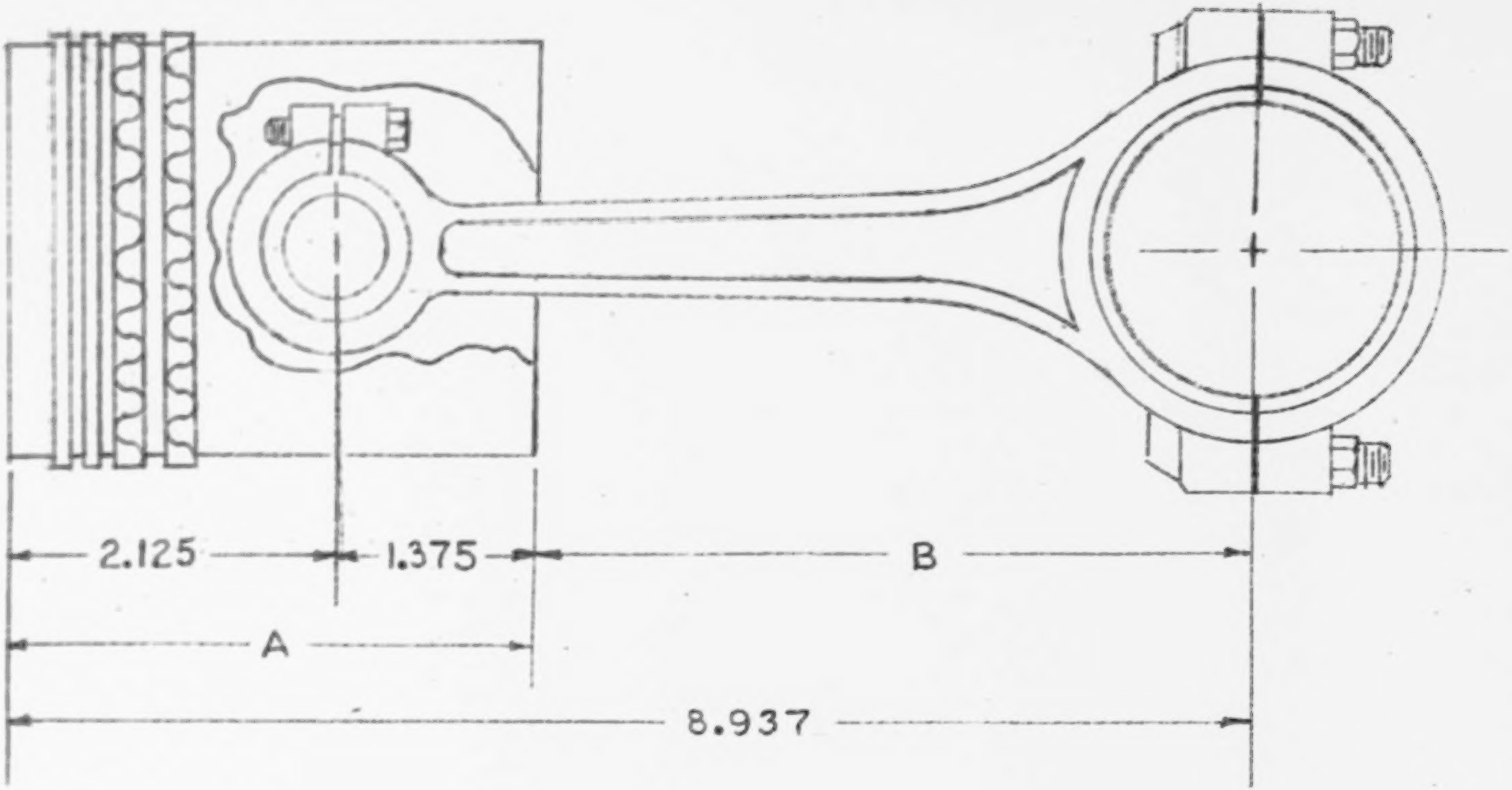
B. Use the 3 transparencies entitled, "Parts of a Piston;" "Crank Shaft for a Four Cylinder Engine;" and "A Simplified View of a Combustible Engine Cylinder." Discuss the piston, rod and crank shaft assembly, and how these items function together. As you discuss the above items, write the names of the various parts on the transparencies.

C. Distribute to each student copies of the sheets which correspond to the transparencies and have the students name the various parts.

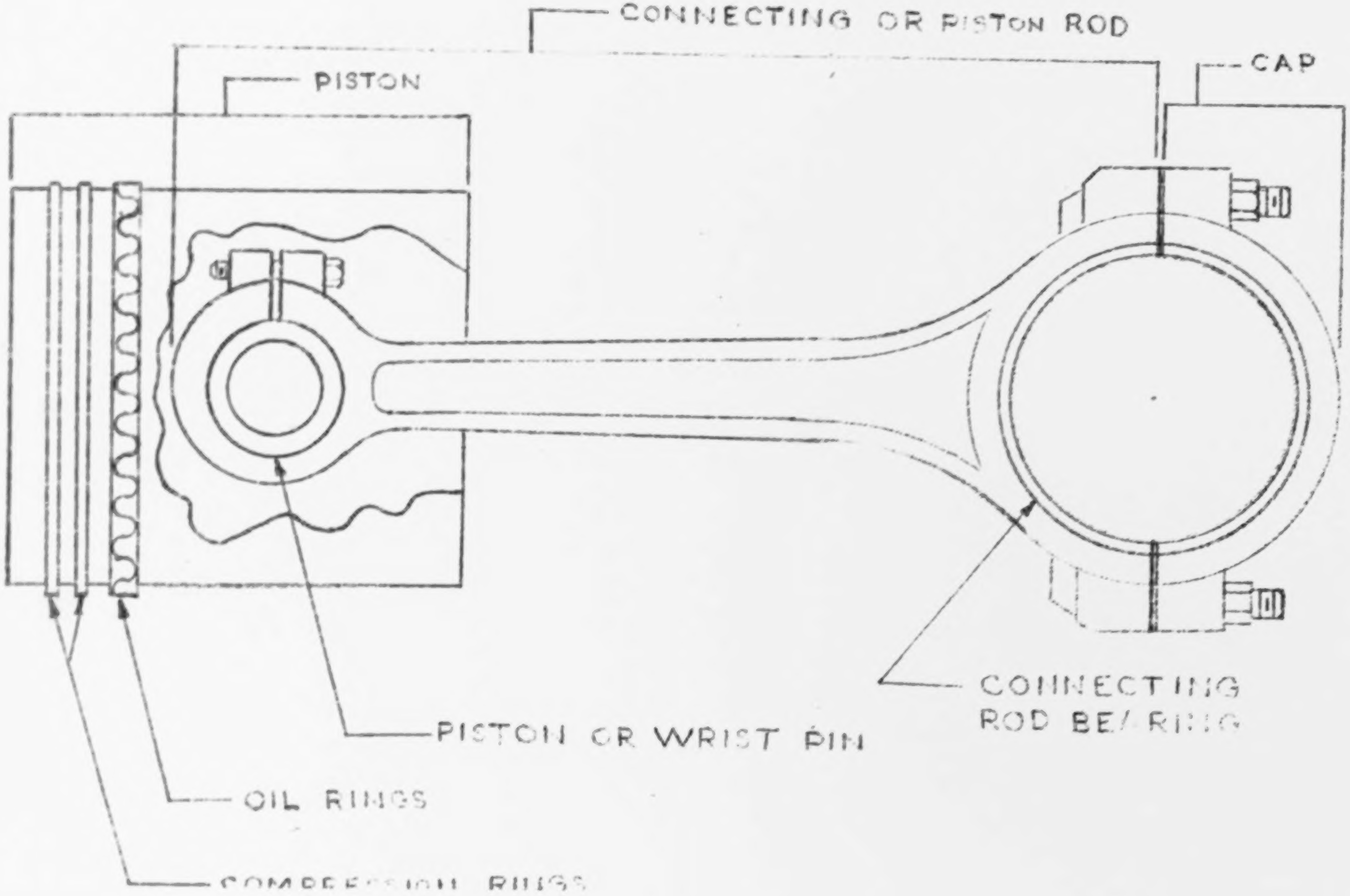
D. Distribute the work sheet entitled, "Pistons and Bore" and have the students answer the questions.

A FOUR RING PISTON

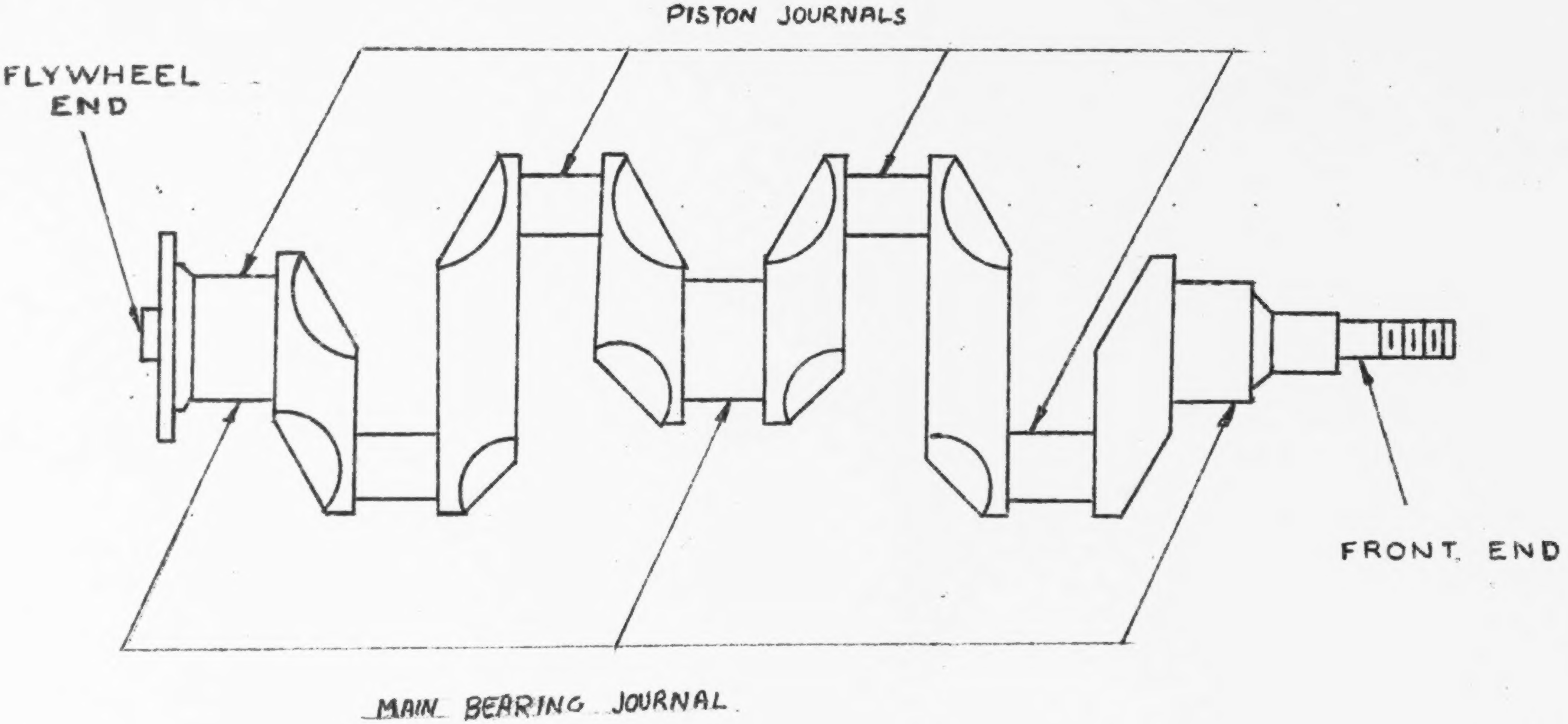
FIND A AND B


2.125
1.375
B
A
8.937

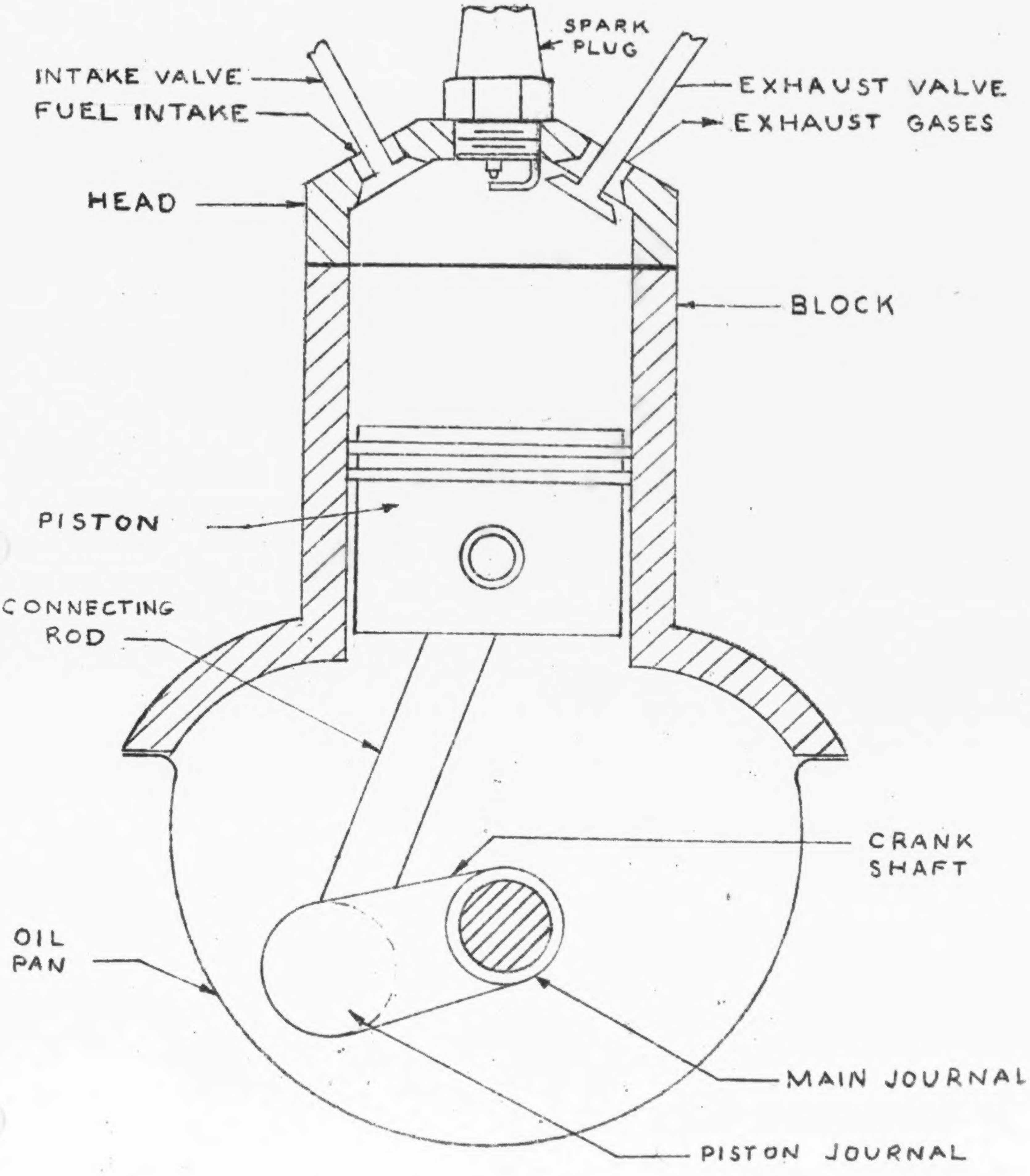
PARTS OF A THREE RING PISTON


CONNECTING OR PISTON ROD
CAP
PISTON
CONNECTING ROD BEARING
PISTON OR WRIST PIN
OIL RINGS
COMPRESSION RINGS

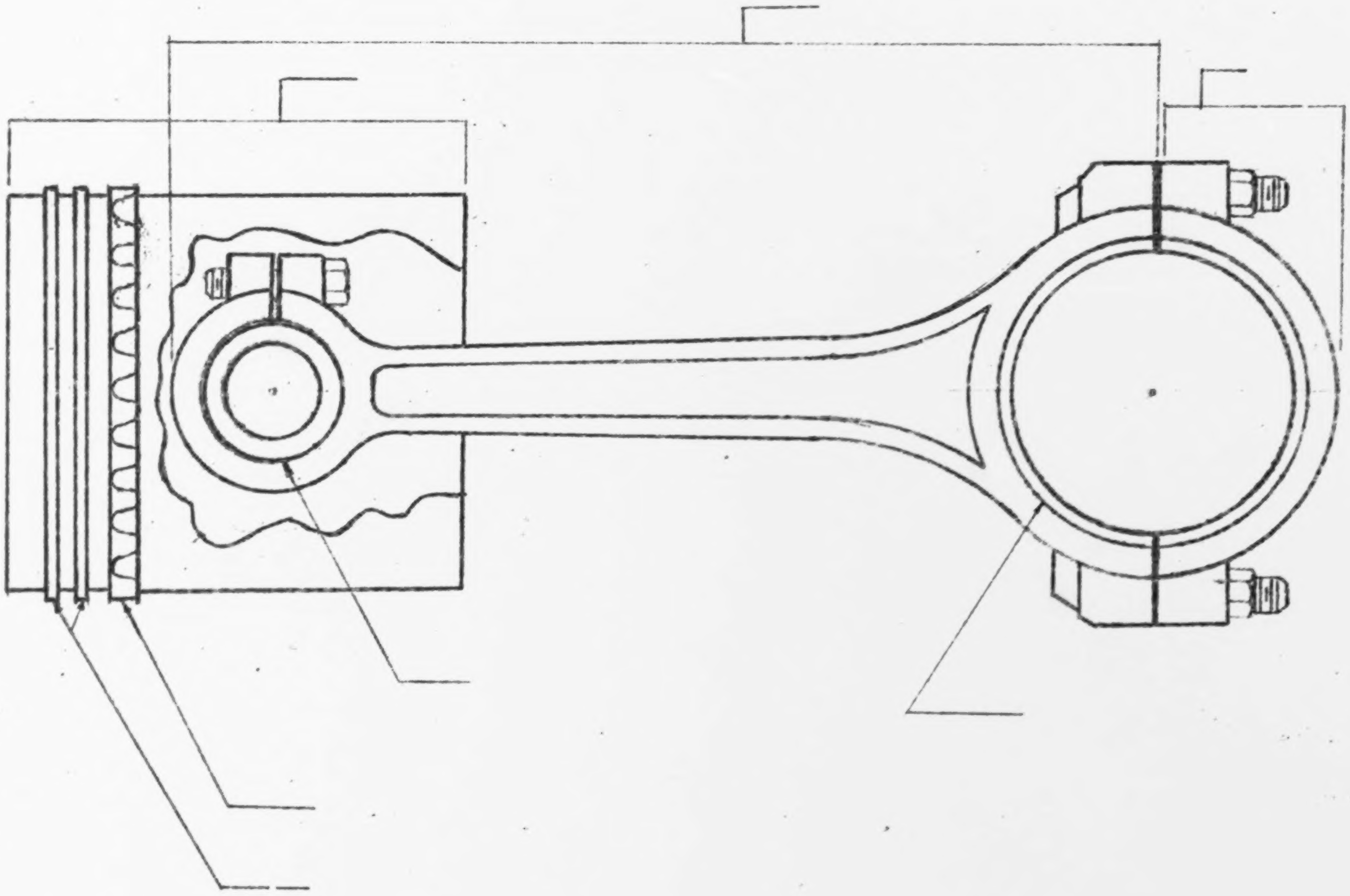
CRANK SHAFT OF A FOUR CYLINDER ENGINE


PISTON JOURNALS
FLYWHEEL END
FRONT END
MAIN BEARING JOURNAL

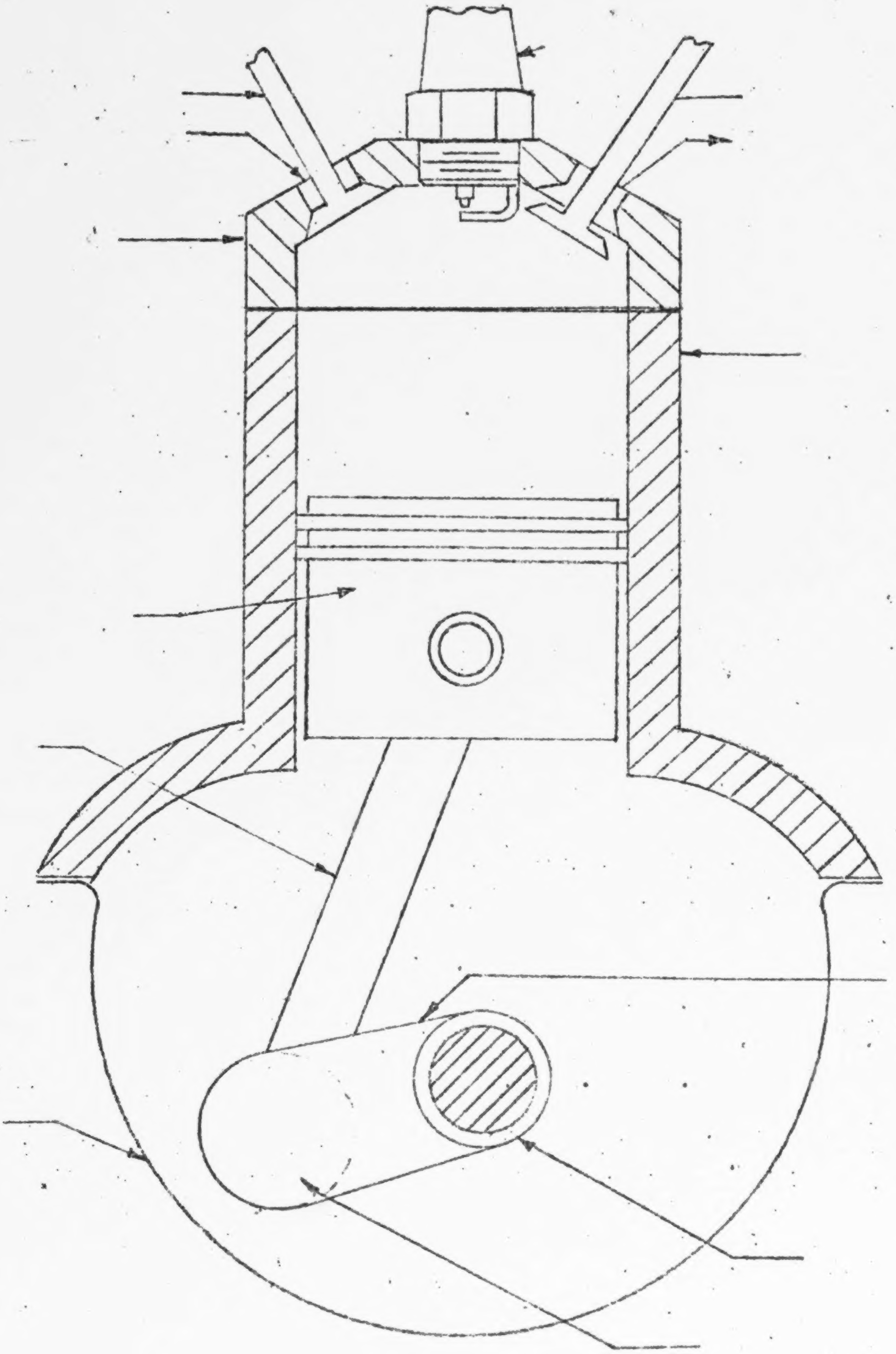
A SIMPLIFIED FRONT CUTAWAY VIEW OF A COMBUSTIBLE ENGINE


SPARK PLUG
INTAKE VALVE
FUEL INTAKE
EXHAUST VALVE
EXHAUST GASES
HEAD
BLOCK
PISTON
CONNECTING ROD
CRANK SHAFT
OIL PAN
MAIN JOURNAL
PISTON JOURNAL

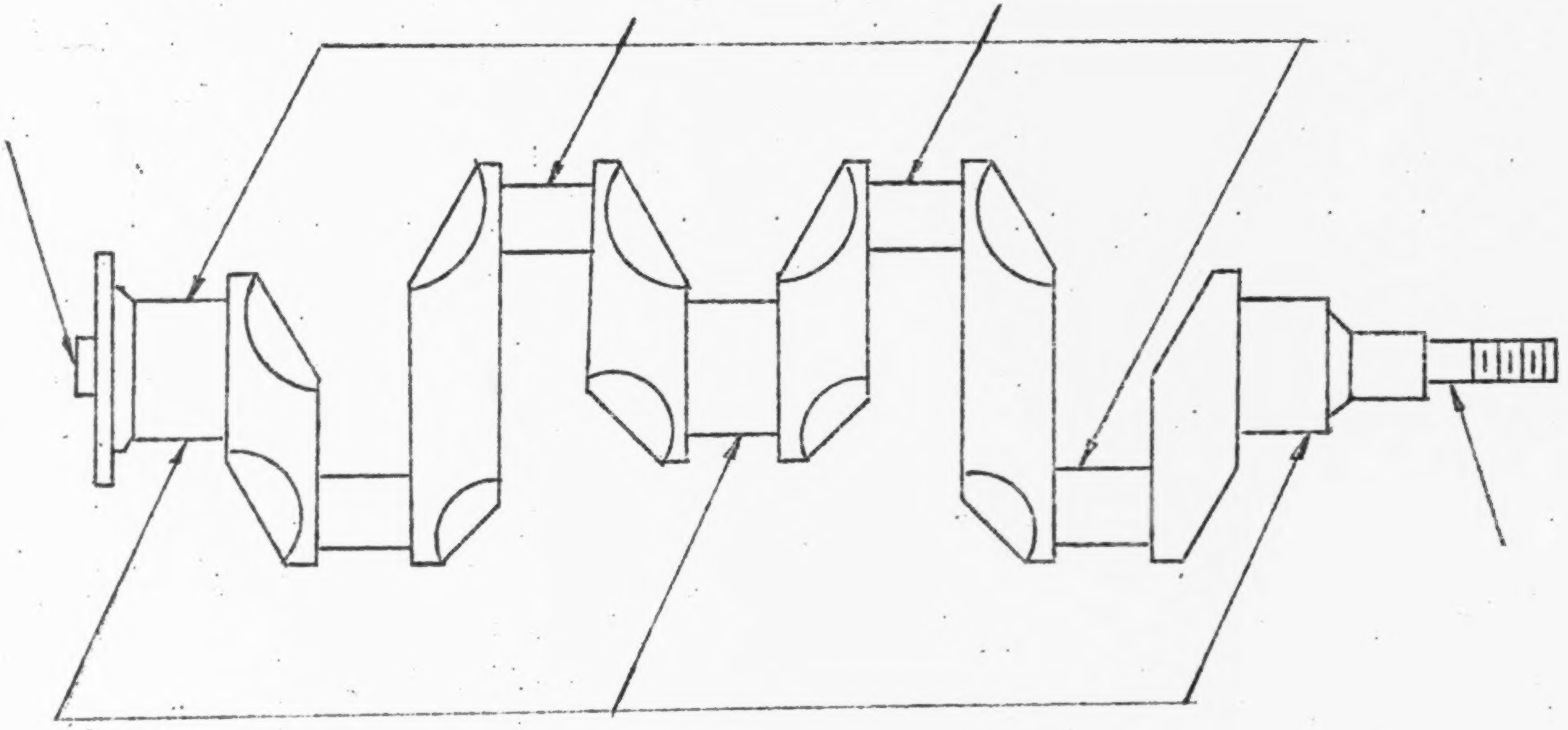
PARTS OF A THREE RING PISTON



A SIMPLIFIED FRONT CUTAWAY VIEW OF A COMBUSTIBLE ENGINE .



CRANK SHAFT OF A FOUR CYLINDER ENGINE



PISTONS AND BORE

1. If you were doing a ring job on a V-8 motor that had 4 ring pistons, how many compression rings would you need? How many oil rings would you need? If coil rings cost $1.17 each and compression rings are 73¢ each, what is the total cost of the rings?

2. If the standard width of a certain piston ring is .1875" and the ring is "miked," .1840, how much has it worn?

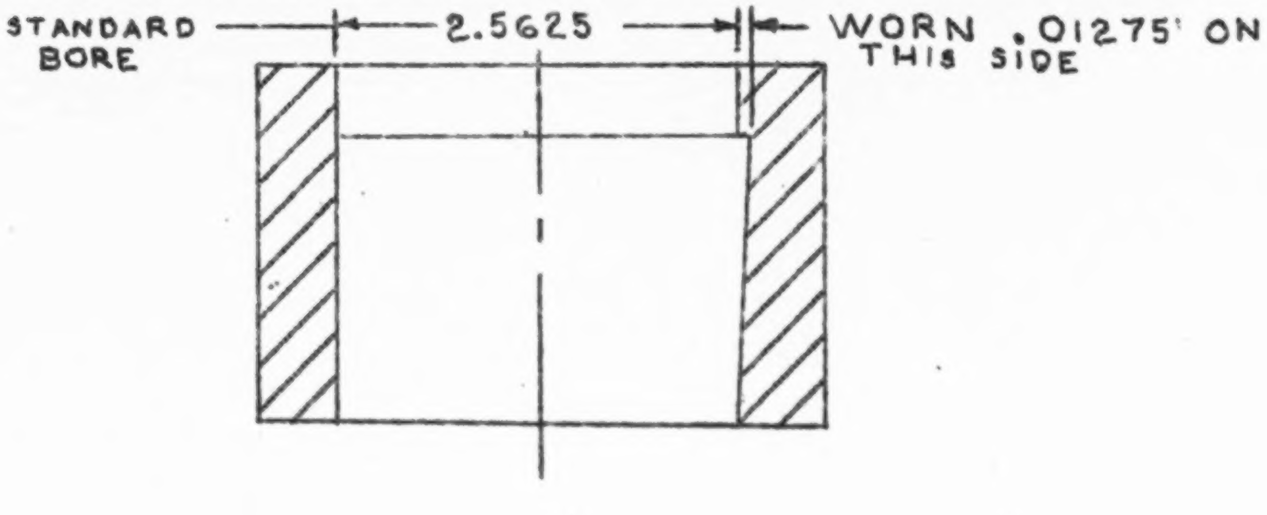
3. The diameter of a new piston is 3.375". If the average wear per 10,000 miles is .006" at all points on the piston, what will the total wear be after 80,000 miles? What should the diameter be after 80,000 miles?

4. When cold an aluminum piston has a diameter of 3.875". When heated it measures 3.882". What is the amount of expansion?

5. When cold an aluminum piston has a diameter of 3.882. When the piston is heated it expands .004". To have a .002" clearance what must be the bore of the cylinder.

6. A piston pin wore a groove in a cylinder wall .012" deep on one side and .0075" deep on the other. If the cylinder is to be rebored what size should it be in order to clean up the bore? The original size was 3.125".

7. What size should the rebore be to straighten the bore as illustrated?



8. If the standard size of a certain piston is 3.892" and the oversize piston is .019" greater, what is the diameter of the oversized piston?

9. A mechanic wishes to replace the original pistons, which measured 3.125 with pistons .015" oversize. What size should the cylinder be, if .002" clearance is allowed?

10. A cylinder four inches in diameter was ground .030" oversize. What would be the actual size of the piston if this product required .002" clearance?

I. Activity: Stroke, Piston Displacement, Engine Displacement and Compression Ratio

II. Objectives: The student should be able to:

   A. Define stroke, piston displacement, engine displacement, and compression ratio

   B. Compute area of a circle

   C. Compute piston displacement, engine displacement and compression ratio

III. Background Information:

   A. Stroke--the stroke of an engine is the linear distance that a piston moves in its cylinder. The stroke is equal to twice the crank throw (See Topic: Piston, Connecting Rod and Crank Shaft).

   B. Piston displacement--piston displacement is the area of the top of the piston times the length of the stroke (i. e. the volume of the space through which the piston moves). Units of measure are cubic inches or cubic centimeters.

   C. Engine displacement--engine displacement is the total piston displacement of the engine (i. e. piston displacement times the number of cylinders). Units of measure are cubic inches or cubic centimeters.

   D. Compression ratio--compression ratio is the total volume of one cylinder (piston displacement and volume of the compression chamber) divided by the volume of the compression chamber. The compression ratio always has a denominator of one (ex. 8.5:1).

IV. Materials:

   A. Transparency entitled, "Displacements"

   B. Student work sheets entitled, "Displacements" and "Get Smart"

   C. Optional: A piston and rod, an engine block, and an engine head.

V. Suggested Procedure:

A. Distribute student work sheets entitled, "Displacements."

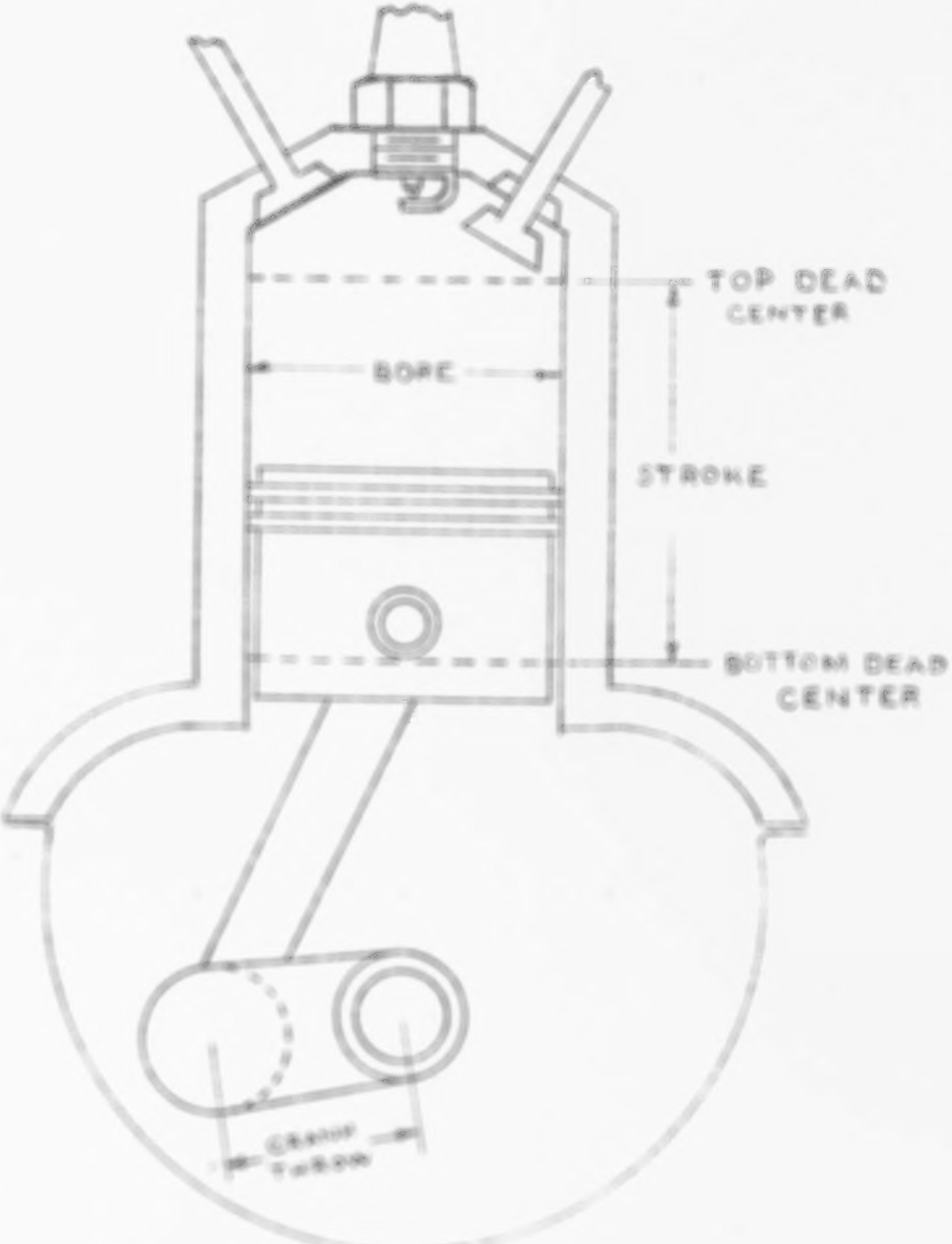
B. Using the transparency "Displacements," discuss stroke, piston displacement, engine displacement, and compression ratio. You might start the discussion by asking questions such as: Who has a bike (small motorcycle)? What size is it? What does this mean? During the discussion, write the names of the various parts and sections on the transparency. Have the students do the same to their work sheets.

C. Distribute "Get Smart" and have the students answer the questions.

ANSWERS FOR "GET SMART"

1. 1.875" x 2 = 3.750 inches
2. 4.188 ÷ 2 = 2.094 inches
3. $41.66\frac{2}{3} \times 6$ = 250 cubic inches
4. 427 ÷ 8 = 53.375 cubic inches
5. 905.6 ÷ 16 = 56.6 cubic inches
6. 36 ÷ 3.5 = 10.2 therefore, the C.R. is 10.2:1
7. 64 + 8 = 72, 72 ÷ 8 = 9 therefore, C. R. is 9:1
8. 41.256
9. 30.51 183.06 10.9:1

DISPLACEMENTS


TOP DEAD CENTER
BORE
STROKE
BOTTOM DEAD CENTER
CRANK THROW

GET SMART

1. What is the stroke when the crank throw is 1.875"?

2. What is the crank throw when the stroke is 4.188"?

3. In a 1968 Chevy, 6 cylinder, 150 H. P. the piston displacement of one cylinder is 41.66 $\frac{2}{3}$ cubic inches. What is the total displacement in the engine?

4. A 1968, 427 cubic inch, V-8, Chevrolet engine has 385 horses. What is the piston displacement in each cylinder?

5. A piston displacement of a certain 16-cylinder engine is 905.6 cubic inches. What is the displacement of one cylinder?

6. What is the compression ratio if there are 35.7 cubic inches of space when the piston is at the bottom of the stroke and only 3.5 inches when the piston is at the top of the stroke?

7. The compression chamber of a cylinder is 8 cubic inches and the piston displacement is 64 cubic inches. What is the compression ratio?

8. A 3.62 inch piston has a crank throw of 1.8. What is the piston displacement?

9. A mechanic found the following measurements on a Buick V-6 engine: Piston 3.6 inches
   Compression chamber volume 3.1 cubic inches
   Crank throw 1.5 inches

   Find the piston displacement, the engine displacement, and the compression ratio of this engine.

BUYING AUTO ACCESSORIES KIT

Teacher Commentary

The purpose of this kit is to provide practice in mathematics through practical applications. Each of the problem cards reviews and reinforces the fundamental operations with whole numbers and decimals.

I. Materials:

Catalog Cards Kit consisting of:

1. One Montgomery Ward catalog
2. One Western Auto catalog
3. Student Order Blanks and Charge Account Applications
4. Twenty-five problem cards separated into three categories:
    a. cards which place limits on the amount of money to be spent
    b. cards for which the amount of money to be spent is unlimited
    c. cards which induce comparative buying

II. Suggested Procedure:

A. The teacher should spend some time demonstrating how to use a catalog. Although students might know how to use the index to find specific items, they will need guidance in reading tables, interpreting prices, calculating tax, and completing an order form.

B. To introduce this activity, the teacher should distribute copies of the order form and a work sheet in which the catalog number, name of item, color or size and price per item are given. Since each teacher can better determine which items might be of interest to his particular class, the work sheet is not included.

C. Once students know how to complete the order form, they should work the problem cards individually or in groups of two. Students should work at their own rate.

D. Since all order forms are similar in design, the students should use the order form provided.

E. Students should complete several cards for Montgomery Ward and several for Western Auto before trying the comparative buying cards.

F. Since the students will be ordering different makes of the same product, there is no way to standardize the prices. One major objective is for students to use the catalog before figuring the costs. Therefore, the teacher should evaluate the student's work by spot checking the order form, looking for reasonable prices, catalog numbers, and totals.

G. Work with the catalog cards may be varied as follows:

   1. Students may order parcel post (mailable items only) where he will have to use the chart to find the cost of the postage.

   2. Students may list shipping weights and be required to find the total weight.

   3. Students may be allowed to make up any original problem of his own.

   4. Students may pay on the extended payment plan where he agrees to pay a specific amount each month until his debt is paid. In this case, the student must complete the credit application.

   If additional cards are needed, copies may be reproduced from the master sheets which follow.

WESTERN AUTO

Auto Owner

For a camping trip that you are preparing to take, purchase the following items from Western Auto to make the ride more pleasant.

2 air ventilated cushions

a baby seat for the car

a luggage carrier

an auto compass

You are limited to spend $32.00. Don't forget the 3% sales tax.

WESTERN AUTO

Auto Owner

Trying to make your car more safe, you order the following from Western Auto:

2 headrests

4 seat belts

1 safety harness for a child riding in a car

1 sealed beam light that can be pluged into the lighter socket

What is the cost of these items? Don't forget the 3% tax.

WESTERN AUTO

Auto Owner

You just bought a 57 Chevy and you would like to "shape it up" a little with:

2 outside mirrors
2 exhaust extensions
1 set of wheel covers for 14" wheels
1 tachometer

You only have $32.00 to spend. Don't forget the 3% tax. Buy from Western Auto.

WESTERN AUTO

Auto Owner

With the advent of spring comes the desire to have a clean shining car. To have such a car you need:

1 chamois
1 sponge
1 tire cleaning brush
1 can of car soap
1 can of one-step polish

What is the cost of a clean, shining car? Include the tax. The store is Western Auto.

WESTERN AUTO

Auto Owner

Your 62, V-8 Chevy needs a few minor repairs which you feel you can do yourself. The items you need are:

a set of the best brake shoes for front and back
a quart of brake fluid
a muffler
two radiator hoses
an exhause pipe and four "U" bolts

Can you buy these items from Western Auto for less than $31.00 including the 3% tax?

WESTERN AUTO

Auto Owner

Winter is coming with its cold mornings and icy roads. You would like to buy a few items from Western Auto for your car to better cope with the problems of winter. If you want to pay cash, how much must you save before you buy the following?

1 pair of 4 ply, 7.75 x 14 white wall, studded, winter tread
1 pair of 4 ply, 7.75 x 14 white wall tires for the front of the car
a 12 volt, 82 amp. battery of good quality

WESTERN AUTO

Auto Owner

You are at a Western Auto store. What will the cost be of the tools listed below:

- a grease gun
- an oil can
- a tire gage
- a jack to be kept in the car's trunk
- a 4-way rim wrench

Don't forget the 3% tax.

WESTERN AUTO

Auto Owner

What's the most it will cost to put new seat covers (front and back), new floor mats (front and back), and fender mud flaps on all four fenders? Tax rate is 3%. The store is Western Auto.

WESTERN AUTO

Auto Owner

What will the parts cost if you want to put window washers, two new horns and warning flashers on your car? Include tax and buy from Western Auto.

WESTERN AUTO

Auto Owner

Harry Hotshot has added to his Mustang the following:

a rear grill
an illuminated Mustang
a Mustang horn
a steering spinner
twin spotlights with mirrors
four curb feelers

What will it cost for you to do the same to your Mustang if you can get a 10% discount from Western Auto? Include tax in the bill.

MONTGOMERY WARD

Auto Owner

With $250.00 to spend, can you buy:

a set of four mag wheels
a pair of wide oval snow tires
a pair of wide oval summer tires

from Montgomery Ward? Don't forget about the 3% tax on the purchase price. Also don't forget about the federal tax.

MONTGOMERY WARD

Student

How much would you pay for the following if you purchased it from Montgomery Ward?

one 260 cc scrambler motorcycle
the best helmet available
a snap-on bubble shield for the helmet
a luggage carrier, seat rail, and bag mount combination
a pair of saddle bags

Have you included the tax?

MONTGOMERY WARD

Auto Owner

What is the least amount that you can spend for:

a 4-track stereo

a set of four 5 in. speakers

four 4-track tapes with the Beatles, Beach Boys, Supremes, and Johnny Mathis

Remember the 3% sales tax.

MONTGOMERY WARD

Auto Owner

You have decided to start changing your own oil and oil filter on your 65 Mustang. What will you pay for:

2 oil filters (buying 2 at a times is cheaper)

a 10 qt. can of Riverside All Season Motor Oil

1 small lubricating gun

1 five pound can of Lithium grease

If you are buying from Montgomery Ward what will be your change if you have a $20 bill? Did you include tax?

MONTGOMERY WARD

Auto Owner

Trying to decide whether you want to repair your present car or buy another second-hand car, you must estimate the cost of the parts needed for the repair work. You can do the work yourself, but you will need the following parts for your 63 Chevy with a 283, V-8.

8 pistons with chromagic rings
a set of standard size connecting rod bearings
a set of standard size crankshaft main bearings

There is a 3% state sales tax on these parts which you are buying from Montgomery Ward.

MONTGOMERY WARD

Auto Owner

After investigating the exhaust system on your 60 Chevy V-8, you find you must replace the entire system. This involves:

2 exhaust pipes
2 front mufflers
2 connecting pipes
2 rear mufflers
2 tail pipes

What will these items cost, including tax, if purchased from Montgomery Ward? What would the exhaust system cost if you didn't have duals but a single system instead?

MONTGOMERY WARD

Auto Owner

You have a forest green 64 Ford convertible which needs a new top. Montgomery Ward has exactly what you want. You are going to buy:

New top pads

A light green top without a glass window. Your glass window is still good.

Two six-inch speakers for the back seat.

Can you buy these items for less than $60?

MONTGOMERY WARD

Auto Owner

You have $50 to spend on your 36 Ford coupe. How many items from the list below can you buy from Montgomery Ward and not exceed your budget limit?

a 15 $\frac{1}{2}$ inch custom steering wheel, black

a black vinyl steering wheel cover

a set of black floor mats

a set of flashing warning lights

a pair of spotlights

Don't forget the sales tax. If you can buy all the items, how much money do you have left? If you cannot buy all the items, which items can you buy?

MONTGOMERY WARD

Auto Owner

You have bought a station wagon to use on your weekly fishing trips. To get the maximum use from the wagon you should have:

a set of curtains for the station wagon
a set of mattresses
a horn-type burglar alarm system
a set of side mount air deflectors
a station wagon splash guard
a good ball type trailer hitch

What will these items cost if purchased from Montgomery Ward? The tax should be included. If a 5% discount were available for paying cash, what would the saving be for a cash customer?

MONTGOMERY WARD

Auto Owner

Anyone who tinkers with his car should have:

an air pressure gage for tires
a tire pump
a spark plug wrench
a grease gun
a can opener spout or a funnel
a four way lug wrench
an oil can
a small socket wrench set

How much would you invest in tools if you had these items? Buy from Montgomery Ward and pay a 3% sales tax.

COMPARATIVE BUYING

Auto Owner

You have a car that you plan to sell after you make some minor repairs. You are concerned about the money you have to spend. With this in mind, where would you buy the following for a 1960, V-8 Chevy, Montgomery Ward or Western Auto?

a set of shocks (front and back)
a set of plugs
a set of floor mats (front and back)
a set of four wheel covers

What would the bill be from each store?

COMPARATIVE BUYING

Auto Owner

If you are going to buy all the following items from one store, would you deal with Montgomery Ward or Western Auto?

4 - wide oval, 4 ply tires
1 - 12 volt battery with a minimum guarantee of 24 months
1 set of heavy-duty shocks for the back

What would be the total bill including tax?

COMPARATIVE BUYING

Auto Owner

Your father has charge accounts at both Montgomery Ward and Western Auto. He gave you, as a Christmas gift permission to charge a total of $50 on his accounts. What would you buy and from which stores?

COMPARATIVE BUYING

Auto Owner

You have been doing some small auto repair jobs in your garage to pick up a few extra dollars. Montgomery Ward gives you a 10% business discount and Western Auto gives you a 12% discount. Choose the store which gives the best deal on:

Piston, Rings, and Rods
Brake Shoes
An Exhaust System

You must choose the year, model, and make of the car you are working on.

COMPARATIVE BUYING

Auto Owner

From which store, Montgomery Ward or Western Auto, would you buy:

a torque wrench

a 4-way rim wrench

a 6 drawer tool chest with tote tray

1 Loc-Grip pliers

a lock for your tool chest

I. Activity: Put a Tiger in Your Tank--I

II. Objectives: The student should be able to:

A. Fill out accurately a purchase order given the appropriate information

B. Apply the rules for operating with decimals and whole numbers to obtain total costs

III. Background Information:

The Humble Oil and Refining Company has granted permission for us to use their Purchase Order with our students. Most of the terms on the form are self-explanatory.

IV. Materials:

A. Transparency of the Humble Oil Purchase Order

B. Student copies of the Humble Oil Purchase Order

C. Work sheet entitled, "Put a Tiger in Your Tank"

V. Suggested Procedure:

A. Distribute student copies of the Humble Oil Purchase Order.

B. Using the transparency, "Humble Oil Purchase Order," discuss the correct procedure for using the order form.

C. Do a problem with the class. As the students write on their forms, you write on the transparency.

D. Have the students do a problem or two in class or for night work.

E. Correct the problems and save for the next lesson.

PUT A TIGER IN YOUR TANK

In each of the following situations you are a gas station manager. The gas station is your high school Esso Station (e.g. Patapsco Esso Station). The address of the station is your home address and you will be charged for the supplies. The supplier is your teacher located at the school's address. USE YOUR OWN IDEAS FOR ANY DATA NOT GIVEN BELOW.

1. Your needs are:

   6 rolls of #999 Poly Coated Cloth Tape--2" width @$3.00
   30 gallon drum of lub grease @ $14.00
   3 cases of Esso Uniflow Oil @ $13.20
   2 cases of Esso Extra Oil @ $12.00
   1600 gallons of Esso Plus @ $.177

2. Your needs are:

   3000 gal. of Esso gasoline @ $.160
   2000 gal. of Esso plus @ $.177
   1600 gal. of Esso extra @ $.193

3. Your needs are:

   1000 gal. of Esso extra @ $.193
   20 Puralator Oil Filters of random sizes @ $1.69
   1 set of hose clamps, part number XB237 @ $27.53
   1 display of radiator hoses of various sizes, part number XK 34-D @ $33.75

4. Your needs are:

1 Gates V-Belt Wall Display, minimum belt stock $38.50

50 foot "Fire-Wall" Heater Hose (type 27BK)
$\frac{1}{2}$ ID @ 5 ¢ per foot
50 foot "Fire-Wall"Heater Hose (type 27BK)
$\frac{1}{2}$ ID @ 6 ¢ per foot
100 foot "Fire-Wall" Heater Hose (type 27 BK)
$\frac{7}{8}$ ID @ $7\frac{1}{2}$" ¢ per foot

CHASE ORDER

SAMPLE

RENDER INVOICES IN QUADRUPLICATE TO
HUMBLE OIL & REFINING COMPANY
P.O. BOX 1286
BALTIMORE, MD. 21203

DATE 9-24-68

ORDER NUMBER (SHOW ENTIRE NUMBER) 6107

SUPPLIER

Mr. Teacher
8100 Wise Avenue
Baltimore, Maryland 21222

DELIVER OR SHIP TO

THIS ORDER NUMBER MUST APPEAR ON ALL DOCUMENTS, PACKAGES SHIPPING TAGS, AND CORRESPONDENCE PERTAINING TO THIS ORDER

Patapsco Esso Station
34-D Oak Grove Drive
Baltimore, Maryland 21220

ED AT DESTINATION ON OR BEFORE	SHIP VIA	TERMS OF PAYMENT
9-30-68	Truck	Cash

UANTITY	UNIT OR PART NO.	DESCRIPTION	UNIT PRICE	AMOUNT	
6	Rolls	#99 Poly Coated Cloth Tape-2"	3.00	18	00
1	30 gallon drum	Lub. Grease	14.00	14	00
3	Case	Esso Uniflow Oil	13.20	39	60
2	Case	Esso Extra Oil	12.00	24	00
1600	Gallon	Esso Plus Gasoline	.177	283	20

TION OF WORK	NO.	CHARGE TO
Near Dundalk		John Student

S ORDER SUBJECT TO TERMS
ID CONDITIONS ON FACE AND
VERSE SIDE OF FIRST PAGE.

ISSUED AT	
Baltimore Terminal	
BY Tom Sophmore	DATE 9-25-68

SAMPLE

ORIGINAL

URCHASE ORDER

SAMPLE

RENDER INVOICES IN QUADRUPLICATE TO
HUMBLE OIL & REFINING COMPANY
P.O. BOX 1288
BALTIMORE, MD. 21203

DATE ▶ 67

ORDER NUMBER (SHOW ENTIRE NUMBER) 610

SUPPLIER

DELIVER OR SHIP TO

THIS ORDER NUMBER MUST APPEAR ON ALL DOCUMENTS, PACK
SHIPPING TAGS, AND CORRESPONDENCE PERTAINING TO THIS C

ANTED AT DESTINATION ON OR BEFORE	SHIP VIA	TERMS OF PAYMENT

QUANTITY	UNIT OR PART NO.	DESCRIPTION	UNIT PRICE	AMOUNT

OCATION OF WORK	NO.	CHARGE TO

THIS ORDER SUBJECT TO TERMS AND CONDITIONS ON FACE AND REVERSE SIDE OF FIRST PAGE.		ISSUED AT	
		BY	DATE

SAMPLE

ORIGINAL

I. Activity: Put a Tiger in Your Tank--II

II. Objectives: The student should be able to:

A. Fill out accurately an invoice form given the appropriate information

B. Apply the rules for operating with decimals and whole numbers to obtain a total cost for the invoice form

III. Background Information:

The Humble Oil and Refining Company has granted permission for us to use their "Delivery Ticket and Invoice/Bill of Lading" form with our students. This ticket is used by the delivery truck driver. Most of the items on the form are self-explanatory, but the following might need clarification.

Tank Truck--(1) "Own" means that the truck belongs to Humble; (2) "Outside" means that the truck belongs to an outside contractor.

Dray Truck--used for delivery of package goods such as oil, tires, batteries, etc.

At Plant--means customer will pick up the merchandise at the plant.

TC--means delivered by tank car

BGE--means delivered by barge

P/L--means delivered by pipe line

Other M/D--means other method of delivery

IV. Materials:

A. Transparency of the Humble Oil Delivery Ticket

B. Student copies of the Humble Oil Delivery Ticket

C. Correct Purchase Orders from yesterday's lesson

V. Suggested Procedure:

A. Distribute student copies of the Humble Oil Delivery Ticket.

B. Using the transparency, "Humble Oil Delivery Ticket," discuss the codes on the ticket and the correct procedure for using the ticket.

C. Using only the purchase order from problem 1 of the previous lesson, "fill out" a delivery ticket with the class. As the students write on their tickets, you write on the transparency.

D. Have the students exchange yesterday's purchase orders with other students and then "fill out" delivery tickets for the purchase orders they now have.

E. Have the students write delivery tickets for all the purchase orders from yesterday's lesson.

SAMPLE

MAY BE
ABLE TO
BLE"
ERY TICKET
NVOICE/BILL OF LADING

HUMBLE OIL & REFINING COMPANY
P. O. BOX ☐ 504 ☐ 598 ☐ 315 ☐ 892
BALTIMORE, MD. 21203

STATION NAME AND NUMBER

No. 188617

DATE

John Student
Patapsco Esso Station
34-D Oak Grove Drive
Baltimore, Maryland 21220

CUSTOMER/DEALER NUMBER: 123456
CUSTOMER ORDER/REQUISITION:
SHIP VIA: Humble
BILL OF LADING NO.: 7891011
FREIGHT: 0. ☒ PREPAID 1. ☐ COLLECT
TANK TRUCK: 1. OWN ☐ 2. OUTSIDE ☐
DRAY TRUCK: 3. OWN ☒ 4. OUTSIDE ☐
5. AT PLANT | 6. TC | 7. BGE | 8. P/L | OTHER M/D | CLASS TRADE
TERMS
SLSM.
RECEIVED QUANTITY SHOWN HEREON
RECEIVED PAYMENT FOR HUMBLE OIL & REFINING CO.

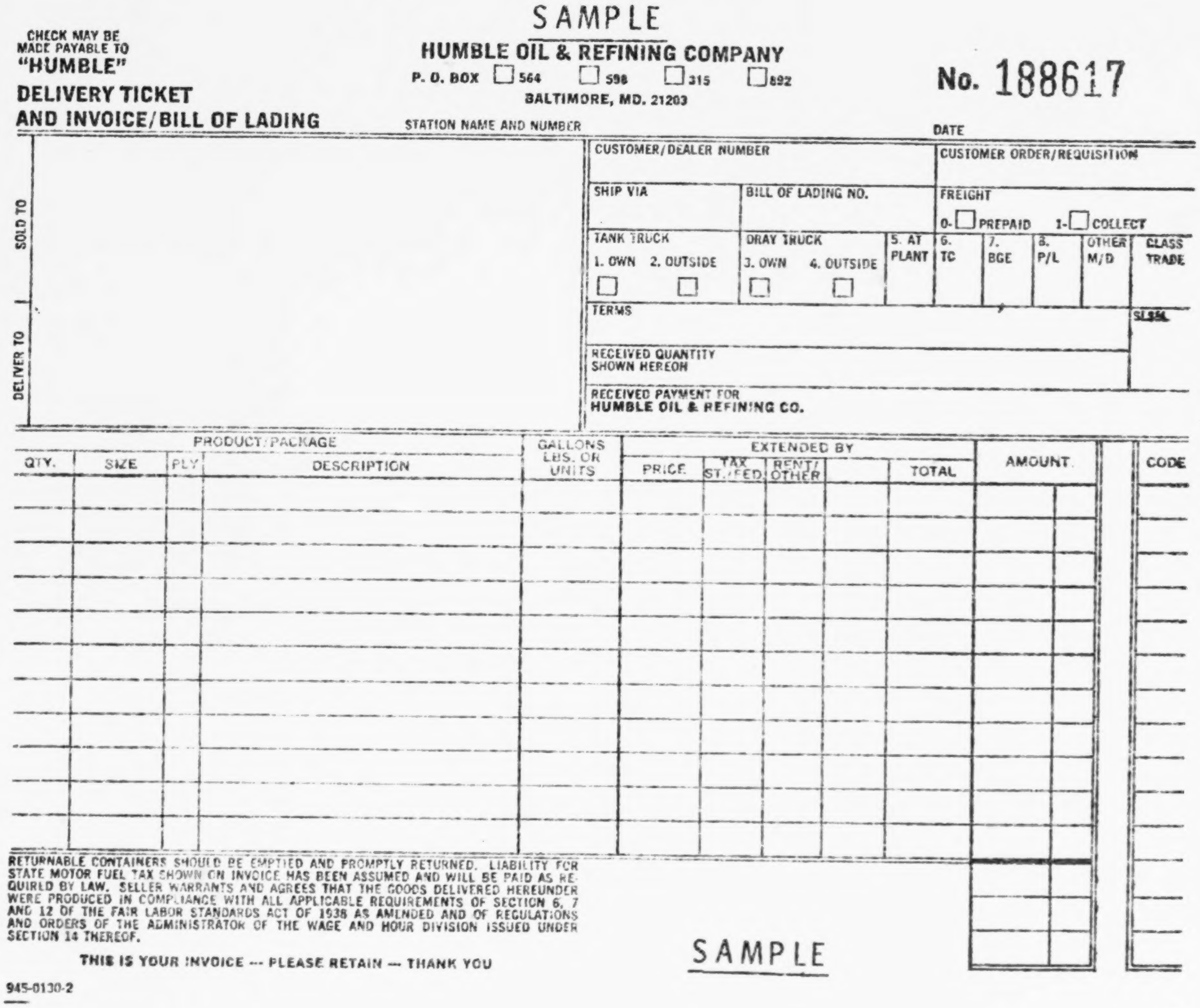
PRODUCT/PACKAGE SIZE	PLY	DESCRIPTION	GALLONS LBS. OR UNITS	EXTENDED BY PRICE	TAX ST./FED	RENT/OTHER		TOTAL	AMOUNT			CODE
2"		#999 Poly Coated Cloth										
		Tape	Rolls	$3.00	$.09			$3.09	18	54		
30 gal.		Lub grease	Drum	14.00	.42			14.42	14	42		
		Esso Uniflow Oil	Case	13.20	.40			13.60	40	80		
		Esso Extra Oil	Case	12.00	.36			12.36	24	72		
		Esso Extra	1600	.193	.11	.01		.313	500	80		
									599	28		

BLE CONTAINERS SHOULD BE EMPTIED AND PROMPTLY RETURNED. LIABILITY FOR TOR FUEL TAX SHOWN ON INVOICE HAS BEEN ASSUMED AND WILL BE PAID AS RE- BY LAW. SELLER WARRANTS AND AGREES THAT THE GOODS DELIVERED HEREUNDER ODUCED IN COMPLIANCE WITH ALL APPLICABLE REQUIREMENTS OF SECTION 6, 7 OF THE FAIR LABOR STANDARDS ACT OF 1938 AS AMENDED AND OF REGULATIONS ERS OF THE ADMINISTRATOR OF THE WAGE AND HOUR DIVISION ISSUED UNDER 14 THEREOF.

THIS IS YOUR INVOICE --- PLEASE RETAIN --- THANK YOU

-2

SAMPLE



SAMPLE

CHECK MAY BE
MADE PAYABLE TO
"HUMBLE"

DELIVERY TICKET
AND INVOICE/BILL OF LADING

HUMBLE OIL & REFINING COMPANY
P. O. BOX ☐ 564 ☐ 598 ☐ 315 ☐ 892
BALTIMORE, MD. 21203

No. 188617

STATION NAME AND NUMBER

DATE

SOLD TO

DELIVER TO

CUSTOMER/DEALER NUMBER						CUSTOMER ORDER/REQUISITION				
SHIP VIA		BILL OF LADING NO.				FREIGHT 0-☐ PREPAID 1-☐ COLLECT				
TANK TRUCK 1. OWN ☐	2. OUTSIDE ☐	DRAY TRUCK 3. OWN ☐	4. OUTSIDE ☐	5. AT PLANT	6. TC	7. BGE	8. P/L	OTHER M/D	CLASS TRADE	
TERMS										
RECEIVED QUANTITY SHOWN HEREON										
RECEIVED PAYMENT FOR HUMBLE OIL & REFINING CO.										

PRODUCT/PACKAGE				GALLONS LBS. OR UNITS	EXTENDED BY					AMOUNT	CODE
QTY.	SIZE	PLY	DESCRIPTION		PRICE	TAX ST./FED	RENT/ OTHER		TOTAL		

RETURNABLE CONTAINERS SHOULD BE EMPTIED AND PROMPTLY RETURNED. LIABILITY FOR STATE MOTOR FUEL TAX SHOWN ON INVOICE HAS BEEN ASSUMED AND WILL BE PAID AS REQUIRED BY LAW. SELLER WARRANTS AND AGREES THAT THE GOODS DELIVERED HEREUNDER WERE PRODUCED IN COMPLIANCE WITH ALL APPLICABLE REQUIREMENTS OF SECTION 6, 7 AND 12 OF THE FAIR LABOR STANDARDS ACT OF 1938 AS AMENDED AND OF REGULATIONS AND ORDERS OF THE ADMINISTRATOR OF THE WAGE AND HOUR DIVISION ISSUED UNDER SECTION 14 THEREOF.

THIS IS YOUR INVOICE — PLEASE RETAIN — THANK YOU

945-0130-2

SAMPLE

I. Activity: Working for Esso

II. Objectives: The student should be able to:

   A. Fill out accurately the Humble Oil purchase order and delivery ticket

   B. Apply the rules for operating with decimals and whole numbers to obtain costs

III. Materials:

   A. Transparencies of the Humble Oil Purchase Order and the Humble Oil Delivery Ticket

   B. Student copies of the above mentioned order form and delivery ticket

   C. Work sheet entitled, "Working for Esso"

IV. Suggested Procedure:

   A. Using as a group activity: Distribute "Working for Esso" and student purchase order forms. Have the students fill in the forms using the information from "Working for Esso." Collect their forms, and at a later date have the same or different students fill out delivery tickets using only information from the purchase form.

   B. As a class activity: Divide the class in half. Give each half a different problem for the purchase form. Then have the halves exchange papers and write up delivery tickets from the purchase forms.

   C. As a class or group activity: Divide the class or small group into teams of two. Allow one team member to be a gas station manager and the other member to be a dispatcher at a district supply depot. Give the station manager the sheet, "Working for Esso," and have him fill out purchase orders. He, in turn, gives only the purchase orders to the dispatcher. The dispatcher then must fill out a delivery ticket.

   The above procedure can be also used as a game.

WORKING FOR ESSO

In each of the following situations you are a gas station manager. The gas station is your high school Esso Station (e.g. Patapsco Esso Station). The address of the station is your school's address and you will be charged for the supplies. The supplier is your teammate located at his home address. Use your own ideas for any data not given below.

1. Your needs are:

   Atlas Windshield Wiper Blades
      10 16SL @ $2.50
      10 18SL @ $3.00
      10 13B @ $1.90
   2 dozen 7 oz. can Atlas Wax @ $.78
   Atlas Thermostats
      half dozen of 331F-331FHT $2.75
      half dozen of 335F-335FHT $2.75
      half dozen of 370F 370 XHT $2.83

2. Your needs are:

   5 pair of No. 11 Chain Adjustors--part number 0211-11 @$2.05
   4 Atlas-Vinyl Topper Mats--part number TM-10 @$6.75
   4 Atlas Wheel Bearings, stock number AT-17304 @$5.92
   1 Alternator, number 710 @$48.95

3. Your needs are:

   2 Generator Pulleys--number 771 @$1.78
   number 783 @$1.95
   2 cases of Esso Uniflow Motor Oil @$13.20
   3 cases of Esso Extra Motor Oil @$12.00
   50 gallon drum of lubricating grease @$20.00

4. Your needs are:

2000 gallons of Esso Extra Gasoline @$.193/gal. +
$.11 Federal tax + $.01 State tax

2000 gallons of Esso Plus @$.177/gal. + same taxes as above

2000 gallons of Esso @$.16 + same taxes as above

5. Your needs are:

A set of Atlas heavy duty shocks--part number 18117 @$13.95

4 Condensers--stock numbers 200, 210, 213, 267 @$1.05

6 Generator Brush Sets --part number 740 @$.85

2 Atlas Universal Joints--stock numbers A-505 and A-514G @$6.50

6. Your needs are:

2 Atlas Mufflers--A-133 @$9.95

1 Atlas Muffler--A331 @$16.14

1 Atlas Muffler--A364 (replaces A357) @$13.85

8 Atlas H. P., 4 ply, 775-14, whitewall tires @$34.72

7. Your needs are:

Atlas Gasoline Filters:

3 of the FF-1 @$1.28
3 of the FF-3 @$2.30
2 of the FF-13 @$ .70
1 of the FF-15 @$5.38

Atlas Oil Filters

2 of the C21 @$1.95
2 of the C21A @$2.10
2 of the G64 @$2.90

8. Your needs are:

3 Atlas Cooling System Cleaners	@$1.20
3 Atlas Cooling System Sealers	@$1.05
3 Atlas Cooling Ssystem Protector	@$1.05
2 Atlas Positive Crankcase Ventilation Valves, V-37(c)	@$2.20

9. Your needs are:

Atlas Auto Lamps--type 53-(12V)	@$.14
type 1154-(6V)	@$.40
type 1157-A-(12V)	@$.63
2 dozen Atlas Gas line anti-freeze	@$.59
Atlas Heater Hose--size $\frac{5}{8}$" ID	@$.40/ft.
size $\frac{3}{4}$" ID	@$.50/ft.
1 dozen Atlas 4 oz. Handy Oil Cans	@$.24

MECHANICS JOB KIT

Teacher Commentary

The purpose of this kit is to provide practice in mathematics through practical applications. Each of the problem cards reviews and reinforces the fundamental operations with whole numbers, decimals, and per cents.

I. Materials: Mechanic's Job Kit consisting of:

  A. Fifty job cards

  B. 2 Service Station Flat Rate Manuals

  C. Four catalogs

    1. AC; 1967 Wholesaler's Catalog--Oil-Air-Fuel Filters

    2. AC; 1968 Wholesaler's Catalog--Spark Plugs

    3. Bower-BCA Bearing plus National Oil Seats Catalog Number 510, 1968

    4. Gates Automotive Products Dealer Catalog, A-3

  D. Service cards

II. Suggested Procedure:

  A. The teacher should spend some time demonstrating how to use the catalogs and manual. The students will need guidance in reading part numbers, interpreting prices, calculating labor costs, taxes and completing a service card. Thus, if you were to put plugs into a 1967 Ford Standard V-8, you would look up the plug number in the AC plug catalog (84TS). Then look up the price of these plugs on the price list ($1.07 each). The next step in the problem to find the labor cost from the flat rate manual (.6 hours to perform the job + .03 hours for personal allowance + .12 hours for job allowance or a total of .75 hours x $7.00 per hour = $5.25). Now you add $8.56 for plugs and the $5.25 for labor. The total cost for the job is $13.81.

B. Once some students know how to use the catalogs and complete the service card, these students can help instruct other students. The students should work the problem cards individually or in groups of two. Allow the students to work at their own rate.

C. All service cards are somewhat similar in design; thus, the students should use the service card provided.

D. Work with the parts catalogs may be varied as follows:

  1. Students may be allowed to make up original problems of their own. They can also vary their labor rate and use the table in the front of the flat rate manual.

  2. Students may bring in service cards from garages and gas stations to use with their original problems or the kit's problems.

E. One major objective is for students to use the catalogs. Therefore, the teacher should evaluate the student's work by checking the correct use of the service form, the cost of the parts and labor, the total costs, and the tax.

1. A 1962 Tempest with a 326-V8 comes in for a tune-up, oil change, and lub job with new air, gas, and oil filters. The parts you have used are:

   1 AC oil filter
   1 AC gas filter
   1 AC air filter
   1 Set of AC spark plugs
   5 Quarts of oil @$0.80

   If the lub job is $1.50, write up a complete service card for the customer.

2. A 1966 Buick Special, V6, is to have 6000 mile maintenance performed on it. The oil is $0.65 a quart. You need 5 quarts for the job. Use an AC oil filter. Fill out a service card for the job.

3. Write up a service card for a 1967 Cadillac with air conditioning that gets a compression test, carburetor adjustment, automatic choke adjustment, brakes adjustment, new AC plugs, and a new AC fuel filter.

4. A 1964 Chevy II, V8, comes into the shop for plugs, air filter, fuel filter, oil filter, oil change, and lub job and a minor tune-up. If 5 quarts of oil @ 65¢ is needed and the lub job is $1.25, fill out a service card for the job.

5. A 1967 Camaro that needs a new water pump ($16.00 for part) is brought into the station. The radiator must be cleaned and flushed, a new radiator cap added plus a fan belt (Gates No. 8224) and the top radiator hose. What will this cost? Complete the service card.

6. A 1961 Chrysler Imperial, V8, 361CID, is to have a minor tune-up, spark plug wires replaced ($12.50 for eight) and new plugs. Complete the service card for this job. Don't forget your labor charge.

7. A 1958 DeSoto needs front wheel outer bearings and both inner and outer rear wheel oil seals. Write out a service card for this job.

8. Write up a service card on a 1963 Dodge Polara for the following work:

Headlights adjusted
Ignition dash switch removed and replaced with a $8.50 model
Brakes adjusted (minor)
Front brake drums replaced
Parking brake adjusted

9. The shop boss gives you a 1965 Mustang to work on. You must do the following:

Install a new $22.50 battery
Replace one $1.07 battery cable
Replace two $0.75 brushes on the generator

Prepare the service card.

10. Job-- T-Bird--1963

Remove and replace both exhaust pipes--parts cost $12.00
Remove and replace both mufflers and both tail pipes--parts cost $35.00
Overhaul alternator and replace both bearings

11. Job-- Lincoln--1965

Adjust both carburetors

Replace gasoline and radiator caps

Replace all wheel bearings and seals for disc brakes

12. Job-- Toronado--1967

Overhaul 4 barrel carburetor

Blow out fuel lines

Overhaul eccentric fuel pump

New plugs

13. Job-- 1963 Oldsmobile, F-85

Replace front wheel outer oil seals on both sides of car

Replace rear axle seals and bearings on both sides

14. Job-- Plymouth Barracuda, 1965, V8

Replace a $2.68 head gasket

Replace a $9.35 ignition coil

Clean and adjust spark plugs--replace 2 with new ones

15. Job-- Studebaker--1964, Hawk, V8

Shocks all around--Front shocks cost @$11.25

Rear shocks cost @$12.10

A $16.00 battery

A pair of battery cables @$3.00

Replace a pair of brushes @$1.20 a pair

16. Job-- 1966 Volkswagen

Replace fan belt

Replace clutch assembly which costs $21.00

Adjust toe-in

Set timing

4 Spark plugs

17. Job-- 1966 Ford Bronco-V8

A new thermostat for 190°

Flush and refill radiator

A new radiator cap

2 new radiator hoses

Replace radiator--$49.50 for radiator

Replace the water pump--$16.37 for pump

18. The shop boss gives you a 1962 Comet to work on. You must do the following:

Install a new $16.37 battery

Replace one $0.98 battery cable

Replace two $0.88 brushes on the generator

Prepare the service card for this job.

19. Job-- Studebaker Lark--1964

Replace exhaust pipes--parts cost $8.00

Replace both mufflers and both tail pipes--parts cost $28.00

Overhaul alternator and replace both bearings

Prepare the service card for this job.

20. Job-- 1963 Chrysler Imperial

Replace all wheel seals and bearings

Replace gasoline and radiator caps

Adjust both carburetors

Write up the service card. Don't forget your labor.

21. Job-- Barracuda--1966

Overhaul the 4-barrel carburetors

Blow-out the fuel lines

Replace the push rod fuel pump which costs $23.86

Install new plugs

22. Job-- 1965 Rambler, 232 cubic inch

Replace air, oil and gas filters

Replace spark plugs

Change oil, 5 quarts @$0.80

Lub job @$1.50

23. Job-- 1962 6 cylinder Dodge Lancer
Semi-annual car care
(5 quarts of oil @ $0.68)

Write up the service card.

24. Write up a service card for a 1964 Turbo Charger Corvair with air conditioning that gets a compression test, carburetor adjustment, automatic choke adjustment, brake adjustment, new AC plugs and fuel filter.

25. A 1961 DeSoto with a standard V-8 and a 4-barrel comes into the shop for plugs, air filter, fuel filter, oil filter, oil change, and lub job and a minor tune-up. If 6 quarts of oil @$0.70 are needed and the lub job is $1.50, fill out a service card for the job.

26. Job-- 1967 Oldsmobile, F-85, V8

Replace water pump ($21.50), radiator must be cleaned and flush

Replace radiator cap

Replace the fan belt (Gates No. 8338)

Replace both radiator hoses

Fill out service card.

90

27. A 1964 Buick Special with a V-6 225 CID is to have a minor tune-up, spark plug wires replaced ($6.38 for a set of 6), and new plugs. Write up a service card.

28. Job-- Chevy II--1962

Replace all bearings and oil seals on all wheels

29. Write up a service card on a 1957 Volkswagen for the following work:

Headlights adjusted
Ignition dash switch replaced with a $5.00 model
Brakes adjusted (minor)
Front brake drums replaced
Parking brake adjusted

30. Job-- 1967 Rebel 290-V8

Oil and lub job
Replace air, fuel and oil filters
Replace plugs
5 quarts of oil @$0.75
Lub job is $1.50

31. A 1965 Ford Falcon V-8 is to have 6000 mile maintenance performed on it. The oil is $0.65 a quart. You need 5 quarts for the job. Fill out a service card for the job.

32. Job-- 1967 Corvette, 327-V8

Test the compression
Replace plugs and fuel filter
Adjust carburetor and automatic choke
Adjust brakes

33. Job-- 1957 Ambassador V8, 343 cubic inch

Replace plugs, air filter, fuel filter, oil filter
Oil change and lub job
A minor tune-up
6 quarts of oil @$0.68 a quart
Lub job is $1.50

34. Job-- 1965 Valiant, 6 cylinder

Semi-annual car care
5 quarts of oil @$0.65

Remember to include your labor charge.

35. A 1967 Toronado is brought into the station. It needs a new water pump ($27.50 for part), the radiator must be cleaned and flushed, a new radiator cap, a fan belt (Gates No. 8411X5) and the top radiator hose. What will this cost? Don't forget your labor.

36. A 1963 Chevelle, V8-283 CID, is to have a minor tune-up, spark plug wires replaced ($8.47 for a set of eight) and new plugs. Write up a service card.

37. Job-- 1961 Dodge Dart

Replace bearings on both front wheels

Replace inner and outer oil seals on both rear wheels

38. Write up a service card on a 1956 Rambler for the following work:

Headlights adjusted

Ignition dash switch removed and replaced with a

$7.25 model

Brakes adjusted (minor)

Front brake drums replaced

Parking brake adjusted

39. You are assigned to work on a Plymouth. Do the following:

Install new brushes--parts cost $1.25
Replace a $1.40 battery cable
Install a new battery--cost $19.84

Prepare the service card.

40. Job-- 1966 Oldsmobile--F-85, V8

Overhaul alternator and replace both bearings
Replace both exhaust pipes, mufflers, and tail pipes--total parts cost is $37.59

41. A 1966 Pontiac with a 326 comes in for a tune-up, oil change, and lub job with a new air, gas, and oil filter. The parts you have used are:

1 AC air filter
1 AC gas filter
1 AC oil filter
1 Set of AC spark plugs
5 quarts of oil @$0.80

If the lub job is $1.50, write up a complete service card for the customer.

42. A 1967 Chrysler, V8, is to have semi-annual car care service. The oil is $0.74 a quart. You need 6 quarts for the job. Use an AC oil filter. Fill out a service card for the job.

43. Write up a service card for a 1966 Jeep that gets a compression test, the carburetor overhauled, the timing set, new plugs, and a new fuel filter. Don't forget your labor.

44. Job-- 1967 Fairlane V-8 with 289

Replace fan belt (Gates No. 8351)
Replace top radiator hose
Replace water pump ($15.00 for part)
Flush and clean the radiator
Replace radiator cap

45. An International Harvester Scout with a 4 cylinder BLD heavy duty engine is to have a minor tune-up, spark plug wires replaced ($5.00 for the set) and new plugs. Write up a service card.

46. Job-- 1957 Ford Falcon--License number BD1732

Replace front wheel outer bearings

Replace inner and outer oil seals on driver's left rear wheel

Write out a service card

47. Write up a service card on a Cougar for the following work:

Headlights adjusted
Ignition dash switch replaced with an $11. 50 model
Brakes adjusted (minor)
Front brake drums replaced
Parking brake adjusted

48. The shop boss assigns a Mercury Meteor to you for the following work:

Install a battery ($14. 00)
Replace 2 battery cables @$1. 04
Replace 2 generator brushes @$1. 19

49. Job-- 1962 DeSoto

Replace the exhaust pipe ($3.50), tail pipe ($1.27), and muffler ($12.75)

Overhaul alternator and replace both bearings

50. Job-- 1966 Pontiac Tempest

Adjust the carburetor

Replace caps on gasoline tank and radiator

Replace all the bearings and seals on all the wheels

BUILDING TRADES ACTIVITIES

I. Activity: Reading a Carpenter's Square

II. Objectives: The student should be able to:

A. Name the parts of a carpenter's square

B. Identify the various scales on a carpenter's square

C. Read various scales on a carpenter's square

III. Background Information:

A. The carpenter's square or steel square may be termed a carpenter's rapid calculator. It is an essential tool with which a beginner should become familiar. It has many graduations and tables on its surfaces which will save many hours in layout problems.

B. In this unit we will attempt to cover the most basic scales on the carpenter's square. We will study the $\frac{1}{10}''$, $\frac{1}{12}''$, $\frac{1}{16}''$, $\frac{1}{8}''$ scales, the octagonal scale, the Essex board measure table, and the rafter table. Other tables that students might be interested are Hip or Valley, Length of Jacks, Side Cut of Jacks, and Side Cut of Hip or Valley.

C. The $\frac{1}{16}''$ and $\frac{1}{8}''$ scales should have been studied when dealing with steel scale unit; if not they should be. In this activity we will emphasize the $\frac{1}{10}''$ and $\frac{1}{12}''$ scales.

IV. Materials:

A. Transparency entitled, "Parts and Graduations of a Carpenter's Square"

B. Work sheet for each student entitled, "Tenths and Twelfths Scales"

C. Transparency entitled, "The Brace Measure Table"

D. Several carpenter's squares for student use

V. Suggested Procedure:

A. Use transparency entitled, "Parts and Graduations of a Carpenter's Square" to point out location of various scales and names associated with it.

B. Hand out carpenter's squares. Allow several minutes for student to become acquainted with the various scales.

C. Use transparency entitled, "The Brace Measure Table" to practice reading $\frac{1}{10}$" scale.

   1. Emphasize there are 10 divisions per inch

   2. Point to various readings and have students identify them

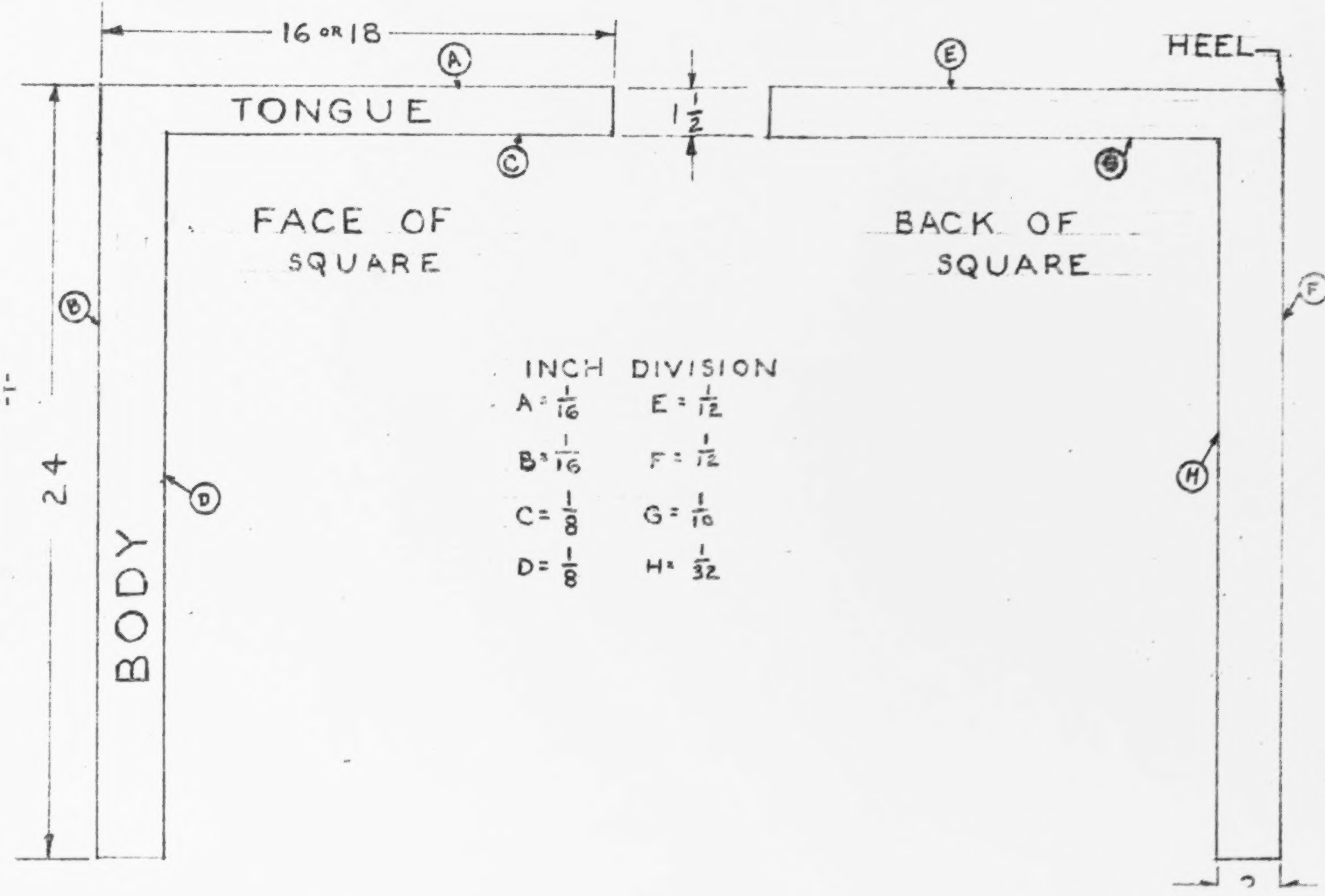
D. Use transparency entitled, "The Brace Measure Table" to practice reading $\frac{1}{12}$" scale.

   1. Emphasize there are 12 divisions per inch

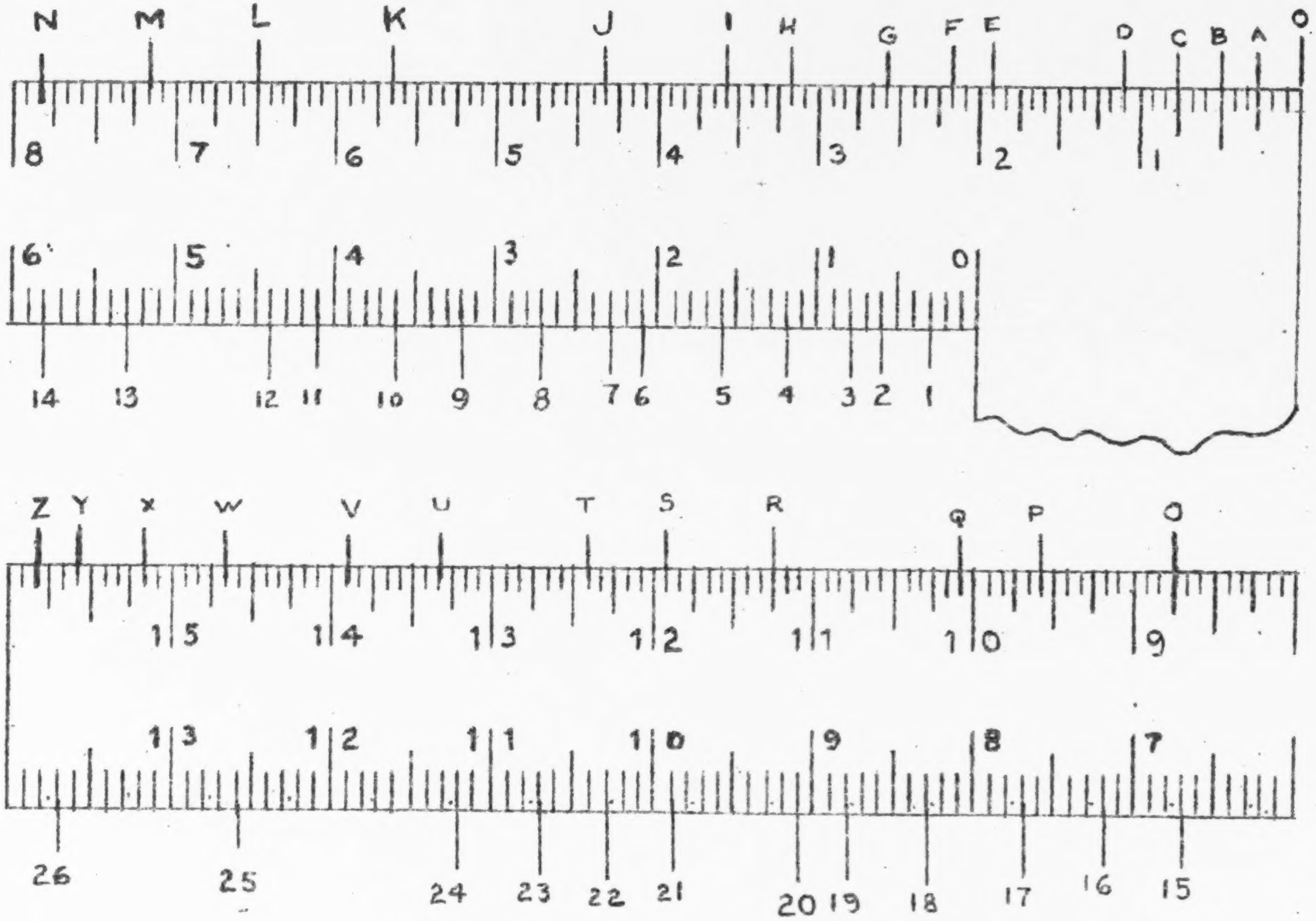
   2. Point to various readings and have students identify them

E. Hand out work sheet entitled, "Tenths and Twelfths Scales" and have students complete.

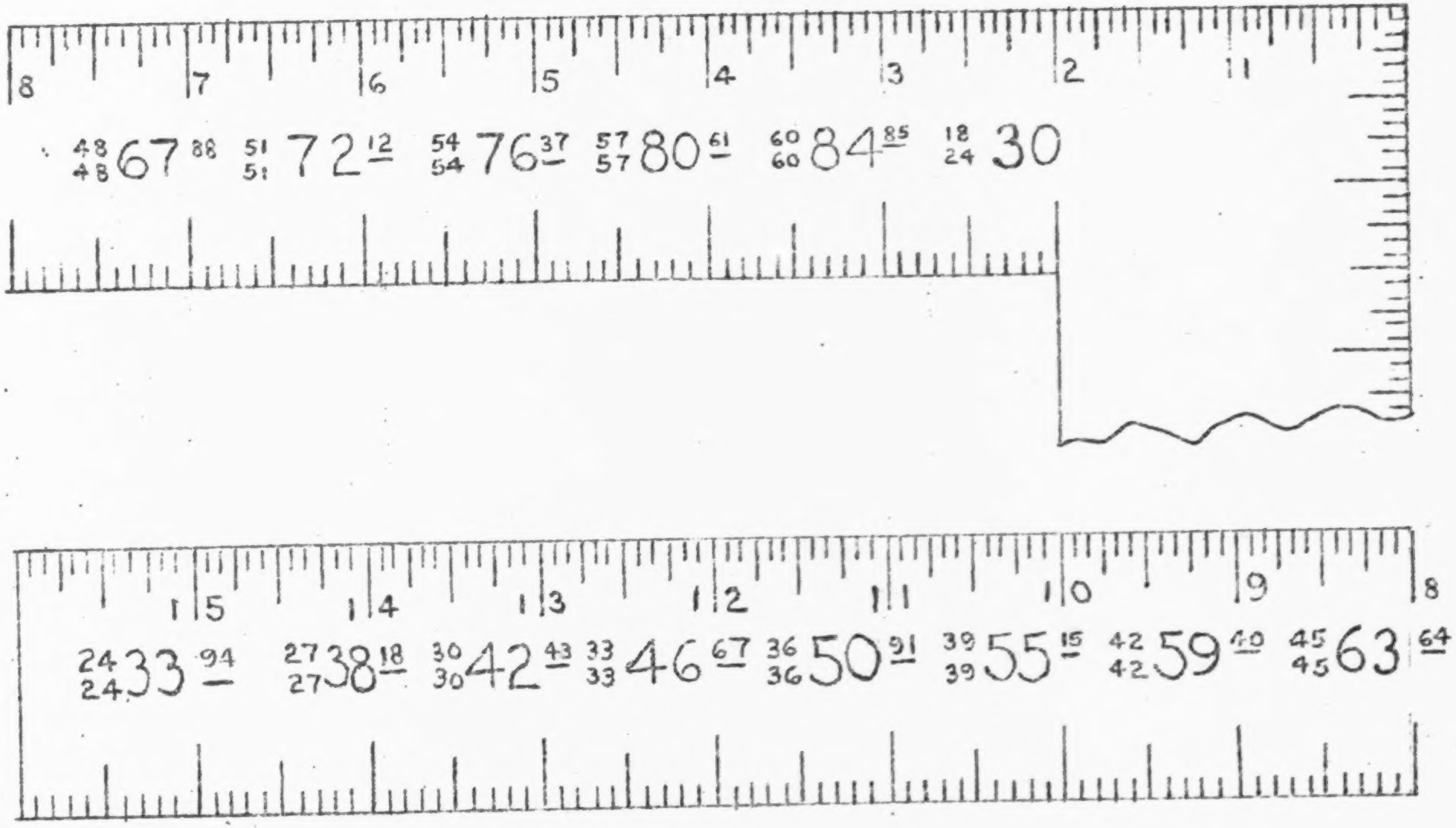
PARTS AND GRADUATIONS OF CARPENTER'S SQUARE


16 OR 18
Ⓐ
Ⓔ
HEEL
TONGUE
1 1/2
Ⓒ
Ⓖ
FACE OF SQUARE
BACK OF SQUARE
Ⓑ
Ⓕ
INCH DIVISION
A = 1/16
E = 1/12
B = 1/16
F = 1/12
C = 1/8
G = 1/10
D = 1/8
H = 1/32
Ⓓ
Ⓗ
24
BODY
2

THE TENTHS AND TWELFTHS SCALES


N M L K J I H G F E D C B A O
8 7 6 5 4 3 2 1
6 5 4 3 2 1 0
14 13 12 11 10 9 8 7 6 5 4 3 2 1
Z Y X W V U T S R Q P O
15 14 13 12 11 10 9
13 12 11 10 9 8 7
26 25 24 23 22 21 20 19 18 17 16 15

THE BRACE MEASURE TABLE


8 7 6 5 4 3 2 11
48 48 67 88 51 51 72 12 54 54 76 37 57 57 80 61 60 60 84 85 18 24 30
15 14 13 12 11 10 9 8
24 24 33 94 27 27 38 18 30 30 42 43 33 33 46 67 36 36 50 91 39 39 55 15 42 42 59 40 45 45 63 64

I. Activity: Framing Terms

II. Objective: The student should be able to:

Identify various parts of a house and label them

III. Background Information:

Read pages 10-16 in Framing, Sheathing and Insulation by Raymond P. Jones, Sr.

IV. Materials:

A. Set of transparencies entitled, "Framing Terms" Part I

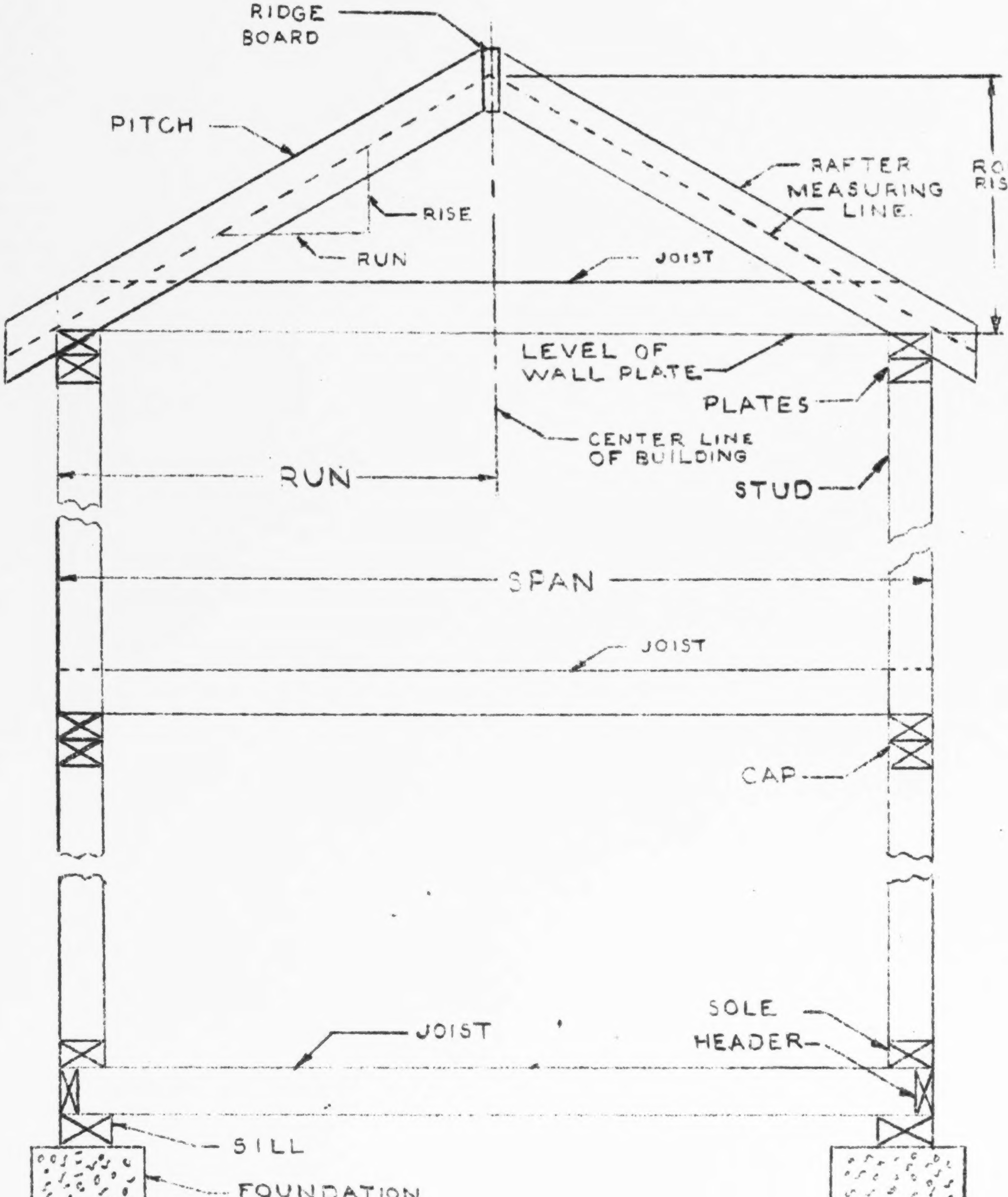
B. Work sheet for each student entitled, "Framing Terms"

V. Suggested Procedure:

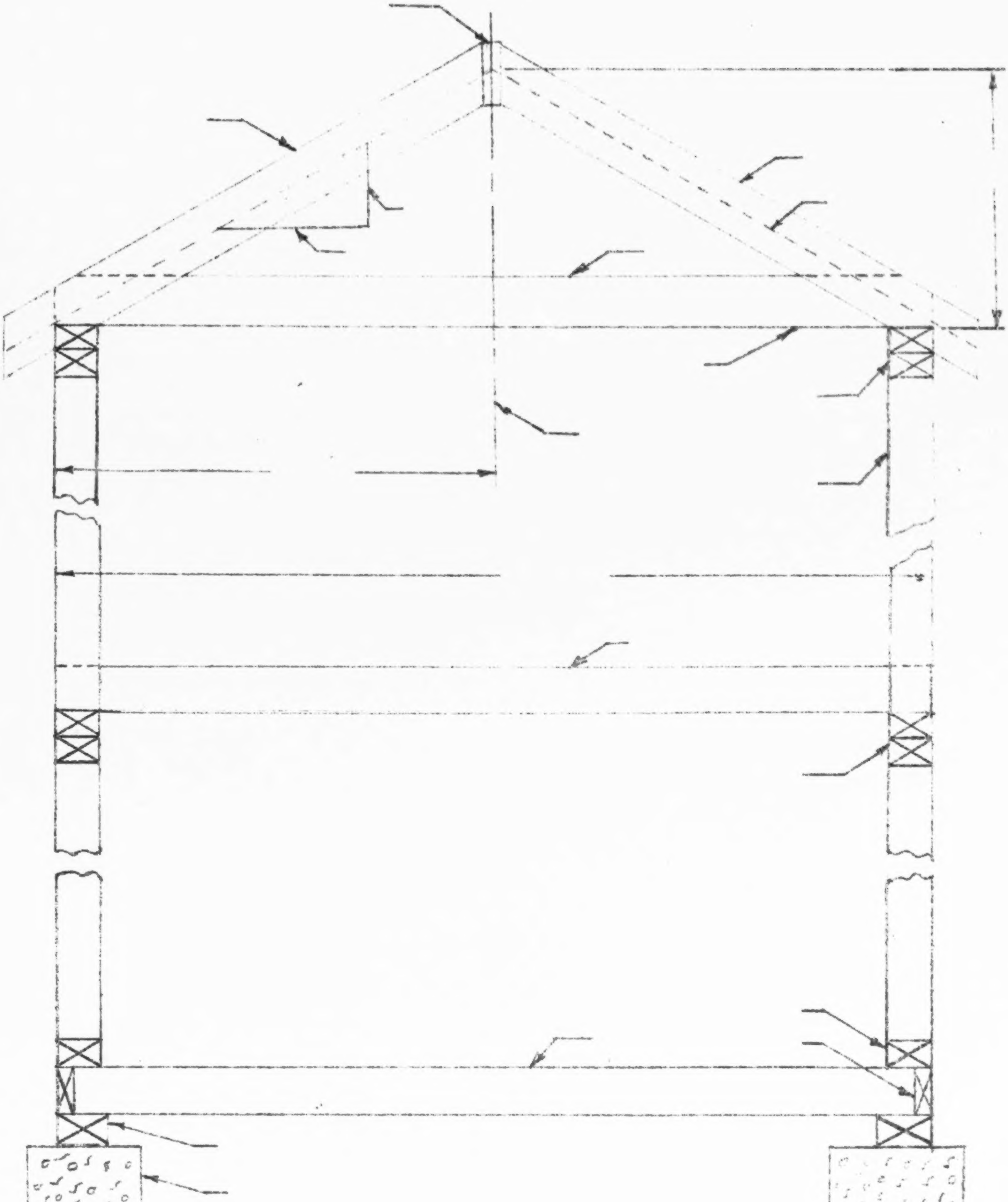
A. Using set of transparencies entitled, "Framing Terms" Part I, point out various parts of a house. Discuss each transparency from background reading.

B. Hand out work sheet and have students identify and label parts of a house. These are the terms with which they should be most familiar.

FRAMING TERMS


RIDGE BOARD
PITCH
RAFTER
MEASURING LINE
ROOF RISE
RISE
RUN
JOIST
LEVEL OF WALL PLATE
PLATES
CENTER LINE OF BUILDING
RUN
STUD
SPAN
JOIST
CAP
SOLE
HEADER
JOIST
SILL
FOUNDATION

FRAMING TERMS



I. Activity: Roofing Terms

II. Objective: The student should be able to:

Define span, run, rise, and pitch

III. Background Information:

A. Before discussing roof framing, certain terms must be understood. The span of a roof is the same as the width of the building. The run of a rafter is one-half of the span. The rise is the vertical distance from the top of the plate to the top of the ridge. The pitch of a rafter is the ratio of the rise to the span. The distance from the outside corner of the plate to the center of the ridge is the rafter length.

B. After completing the section on roofing, a good follow-up activity might be Roof Shingling in textbook, pages 281-290.

IV. Materials:

A. A series of transparencies by 3M entitled, "Roof Framing"

B. Work sheet entitled, "Roof Dimensions"

V. Suggested Procedure:

A. Use transparency entitled, "Roofing Terms" to point out rafter, span, ridge board, plate, rise, run, and pitch.

B. Work the following example: A house has a run of 12 feet and a rise of 8 feet:

1. what would be the span? (12 x 2 = 24)
2. what would be the pitch of the roof? $(\frac{8}{24} = \frac{1}{3})$

C. Hand out work sheet entitled, "Roofing Dimensions." Have students complete columns entitled, "Span" and "Pitch."

ROOF DIMENSIONS

Directions: Complete each of the following columns given the run and the rise of a roof.

Rise	Run	Span	Pitch	(Rise)^2	(Run)^2	(Rise)^2 + (Run)^2	Rafter Length $\sqrt{(\text{Rise})^2 + (\text{Run})^2}$
10'	10'						
6'	12'						
4'	8'						
7'	22'						
9'	6'						
3'	11'						
2'	7'						
4'	9'						
3'7"	16'8"						
2'9"	12'4"						
6'8"	10'5"						
7'2"	13'7"						
9'1"	15'11"						

I. Activity: Rafter Length

II. Objectives: The student should be able to:

A. Find the square of a number by an algorithm

B. Find the square of a number using the table in the textbook

C. Find the square root of a number by an algorithm

D. Find the square root of a number using the table in the textbook

E. Find the length of a rafter

III. Background Information:

A. Students should be familiar with raising a number to a power, but a short review will be necessary. On the other hand, square root may be a new concept to them.

B. The motivation for this lesson is finding rafter length. To raise a number to a power and to find square root is secondary.

IV. Materials:

A. Textbook

B. A work sheet for each student entitled, "Roof Dimensions"

V. Suggested Procedure:

A. On the chalkboard draw a side view of a roof and label the span, rise, run, pitch, and rafter.

B. Tell students, suppose you know the span and rise. Supply numbers.

C. Ask--"Can you find the run?" "What is it?"

D. Ask--"Can you find the pitch?" "What is it?"

E. Ask--"Can you find the rafter length?" This is our problem for today. Mathematicians have discovered that the Pythagorean Theorem,

$C^2 = a^2 + b^2$ or $(\text{rafter length})^2 = (\text{run})^2 + (\text{rise})^2$, will answer this question. We are not interested in the Theorem, but will be using the formula to find rafter length. Notice the formula involves exponents.

F. First, review raising to powers (briefly).

  1. by algorithm
  2. by table in textbook

G. Secondly, show the students how to find a square root.

  1. by algorithm--see either
    a. "Trapping the Root" by Stanley A. Smith or
    b. Standard method--consult Fundamentals of Mathematics by Edwin I. Stein
  2. by table in textbook

H. Using the work sheet entitled, "Roof Dimensions" have students complete the columns headed "$(\text{Rise})^2$", "$(\text{Run})^2$", "$(\text{Rise})^2 + (\text{Run})^2$" and "Rafter Length." Remind the students, it will be necessary to have rise and run in either feet or inches.

I. Activity: Rafter Length Using Carpenter's Square

II. Objective: The student should be able to:

Find the length of a rafter using the table on a carpenter's square

III. Background Information:

A. The rafter table appears on the body of the carpenter's square. We will deal only with the first row of figures which represents the length of common rafters per foot of run. The other five lines of figures in the table will not be discussed, as they are seldom used. Each set of figures under each division mark represents the length of a common rafter per foot of run with a rise corresponding to the number of inches on the division mark. For example, under the 11-inch mark appears 16.28". This represents the length of a rafter with a run of 12" and a rise of 11". Also, under 18-inch mark appears 21.63". This represents the length of a rafter with a run of 12" and a rise of 18".

B. To find the total length of the rafter, the span of the building must first be known. Suppose the building span is 18'8" and the rise is 6" per foot of run. The total run of the rafter will be 9'4". Under the 6-inch mark appears 13.42", which is the length of a rafter with a run of 12" and a rise of 6". To find the total rafter length multiply 13.42 by $9\frac{1}{3}$ and the result will be 125.25". Now change the answer to feet by dividing by 12 (10.44').

IV. Materials:

A. Transparency entitled, "The Rafter Table"

B. Work sheet entitled, "The Length of Common Rafters"

C. Several carpenter's squares for student use

D. Chart entitled, "The Rafter Table"

V. Suggested Procedure:

A. Using transparency entitled, "The Rafter Table", point out the line entitled "Common Rafters per Foot Run" that the students will be using.

B. Hold up a carpenter's square and show the students where the table is located.

C. Show the students, using transparency, how to read "The Rafter Table" as explained in the background information.

D. Show the students how to find the total length of a rafter. Use the example problem given in background information.

E. Hand out chart entitled, "The Rafter Table."

F. Hand out work sheet entitled, "The Length of Common Rafters." Do the first problem with the class.

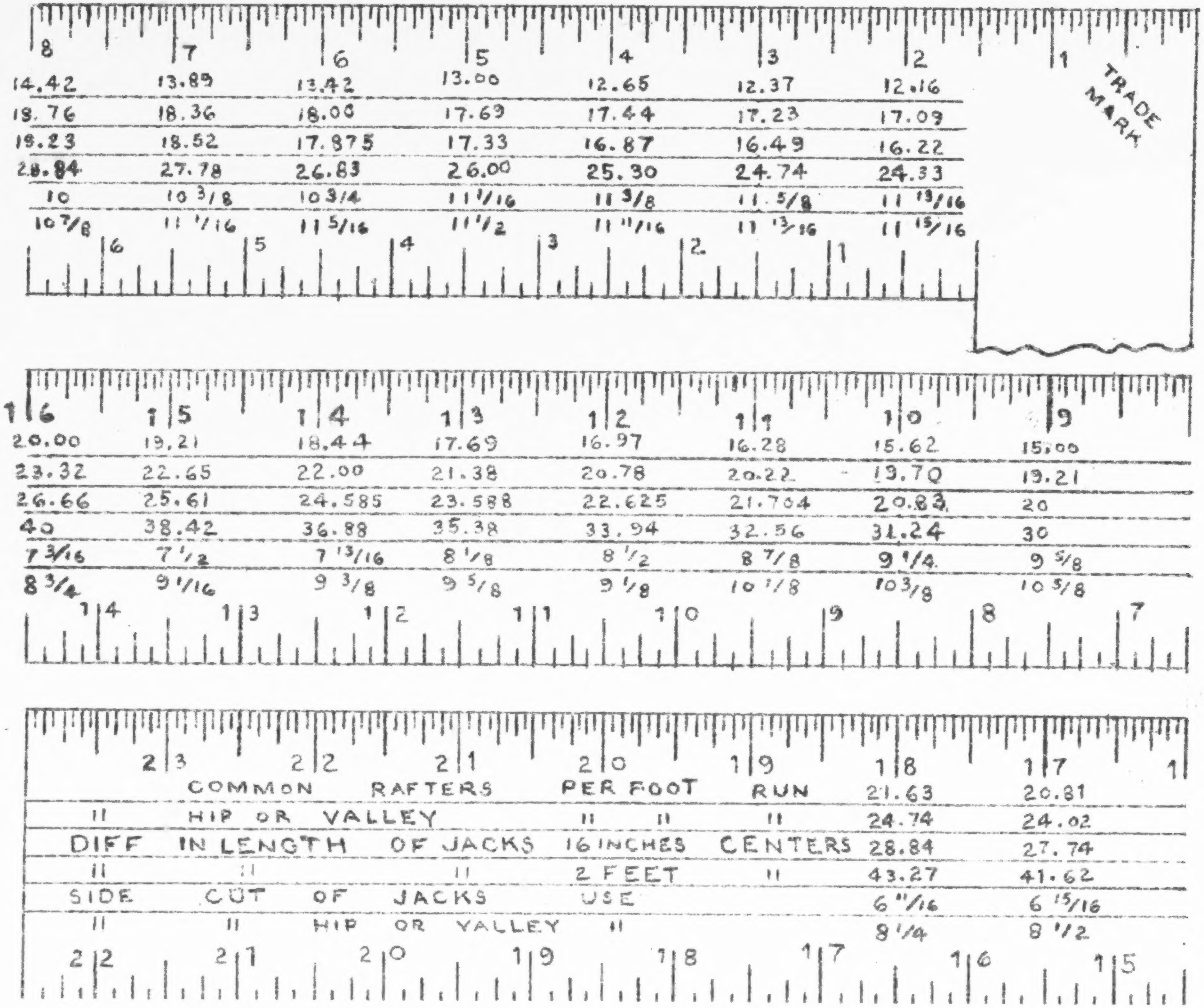
G. Have students complete work sheet.

THE LENGTH OF COMMON RAFTERS

Directions: Compute the length of each common rafter using your Rafter Table.

Building Span	Rise Per Foot	Length of Rafter Per Foot Run	Total Run	Total Length of Rafters in Feet
1. 20'	6"			
2. 14'	2"			
3. 36'	12"			
4. 40'	16"			
5. 24'	8"			
6. 26'	7"			
7. 30'	5"			
8. 28'	3"			
9. 38'	1"			
10. 42'	9"			
11. 20'6"	13"			
12. 14'4"	4"			
13. 36'8"	17"			
14. 40'10"	16"			
15. 24'2"	15"			
16. 26'6"	10"			
17. 30'4"	11"			
18. 28'5"	14"			
19. 38'7"	18"			
20. 42'3"	10"			

THE RAFTER TABLE



	18	17
COMMON RAFTERS PER FOOT RUN	21.63	20.81
" HIP OR VALLEY " " "	24.74	24.02
DIFF IN LENGTH OF JACKS 16 INCHES CENTERS	28.84	27.74
" " " 2 FEET "	43.27	41.62
SIDE CUT OF JACKS USE	6 11/16	6 15/16
" " HIP OR VALLEY "	8 1/4	8 1/2

16	15	14	13	12	11	10	9
20.00	19.21	18.44	17.69	16.97	16.28	15.62	15.00
23.32	22.65	22.00	21.38	20.78	20.22	19.70	19.21
26.66	25.61	24.585	23.588	22.625	21.704	20.83	20
40	38.42	36.88	35.38	33.94	32.56	31.24	30
7 3/16	7 1/2	7 13/16	8 1/8	8 1/2	8 7/8	9 1/4	9 5/8
8 3/4	9 1/16	9 3/8	9 5/8	9 7/8	10 1/8	10 3/8	10 5/8

8	7	6	5	4	3	2
14.42	13.89	13.42	13.00	12.65	12.37	12.16
18.76	18.36	18.00	17.69	17.44	17.23	17.09
19.23	18.52	17.875	17.33	16.87	16.49	16.22
28.84	27.78	26.83	26.00	25.30	24.74	24.33
10	10 3/8	10 3/4	11 1/16	11 3/8	11 5/8	11 13/16
10 7/8	11 1/16	11 5/16	11 1/2	11 11/16	11 13/16	11 15/16

I. Activity: Board Measurement

II. Objectives: The student should be able to:

   A. Define a board foot

   B. Find the number of board feet in a piece of lumber

   C. Find the cost of various quantities of lumber given the price per unit.

III. Background Information:

Read pages 172-176 in textbook

IV. Materials:

A textbook for each student

V. Suggested Procedure:

   A. Ask student, "What is a board foot?" If they don't know, define board foot.

      1. use drawing on page 173 to illustrate one board foot

      2. work the example problems on page 174 on the board

   B. Show and explain the table entitled, "Lumber Table" on page 482.

   C. Select problems from pages 177-181 for students to work.

I. Activity: Board Feet on Carpenter's Square

II. Objective: The student should be able to:

Find the number of board feet in a piece of lumber using a carpenter's square

III. Background Information:

A. The board measure is marked on the back of the square, and enables you to read off the number of board feet a board contains without making any calculations. Under the 12 inch mark, on the outer edge of the steel square, is a column of figures, which refers to the length of the boards to be calculated. The other numbers on the inch scale, to the right and left of the 12 inch mark, refer to the width of the boards.

B. To use the scale, read off the length of the board to be calculated, follow this line to the number indicating its width, and the result is found in the column of figures under that number. For example, a board is 8"wide and 13' long. Find the number of board feet. Find 13 under 12 on the fifth line; follow to the left until you reach 8". The result is 8'8" and is found on the fifth line. This could also be interpreted as $8\frac{2}{3}$ board feet.

C. To find the length of boards longer than 15', divide the length into two parts, find the number of board feet in each part and add them together. For example, to find the number of board feet in a board 14" wide and 21' long divide the length into 10' and 11' lengths and follow these lines to the right until 14 is reached. A 10' board contains 11'-8" and an 11' board contains 12'-10". Adding these figures gives a total of 24'6", or $24\frac{1}{2}$ board feet.

D. The scale is based on 1-inch boards. For 2-inch boards multiply the result obtained by 2.

E. A board 12' long contains as many board feet as its width in inches. Similarly, a 6' board contains half as many board feet as its width. Therefore, the numbers 6 and 12 have been omitted from the column under the 12 inch mark.

IV. Materials:

A. Transparency entitled, "Essex Board Measure Table"

B. Work sheet for each student entitled, "Board Feet"

C. Several carpenter's squares for student use

D. Table for each student entitled, "Essex Board Measure Table"

V. Suggested Procedure:

A. Show the students the transparency entitled, "Essex Board Measure Table."

B. Hold up a carpenter's square and show them where the table is located.

C. Show the students, using the transparency, how to read "Essex Board Measure Table" as explained in the background information. Use example given there.

D. Show the students how to find:

1. the number of board feet which is a board longer than 15'

2. the number of board feet in a board 2", 3", etc. thick

E. Explain to the students why 6' and 12' lengths of boards are not on the table.

F. Hand out the work sheets and table.

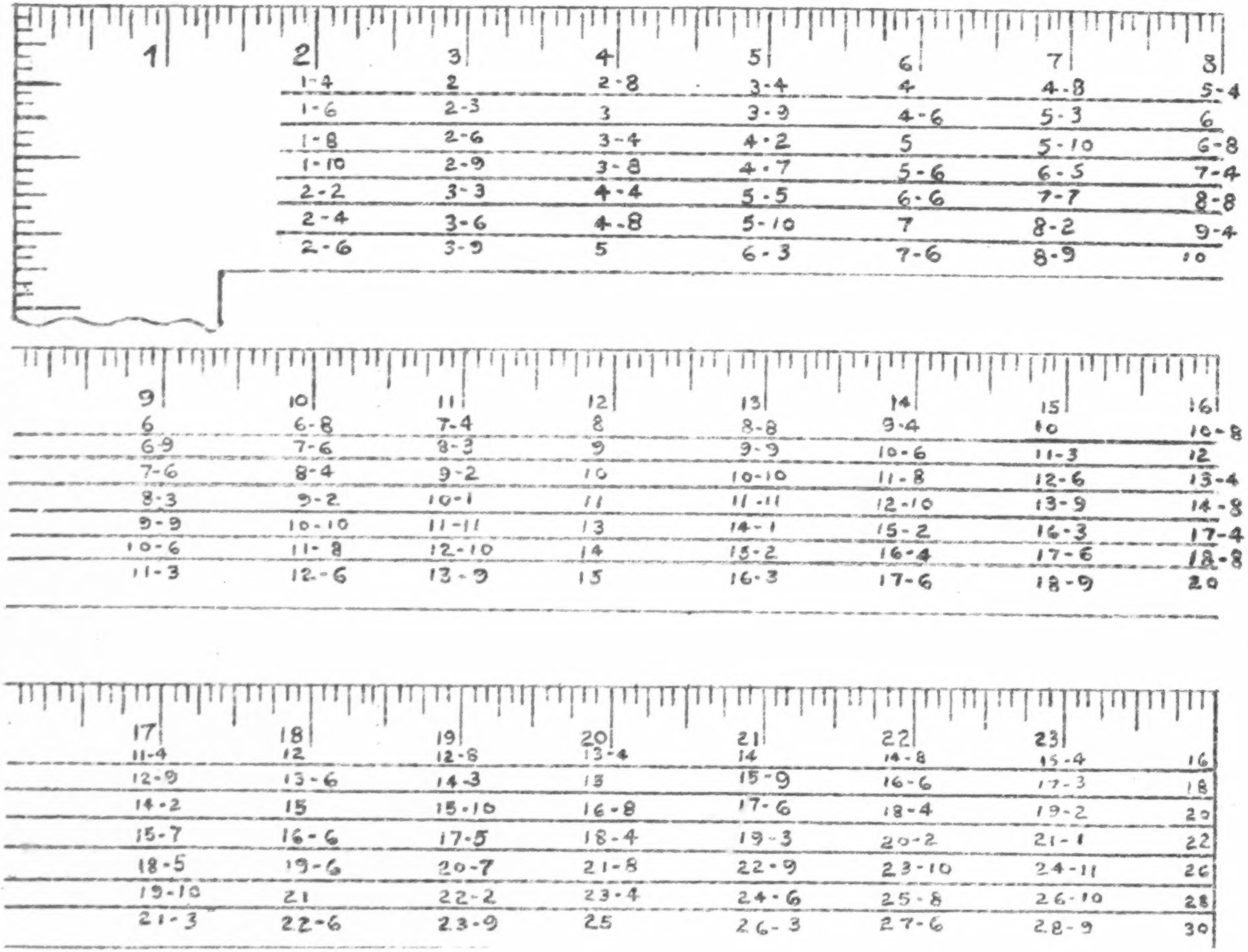
G. Tell the student to complete work sheet using table.

BOARD FEET

Directions: Use your "Essex Board Feet Table" to find the number of board feet in each of the following boards.

Board Size		Number of Board Feet
1.	1" x 6" x 8'	
2.	1" x 10" x 10'	
3.	1" x 4" x 8'	
4.	1" x 8" x 14'	
5.	1" x 12" x 15'	
6.	1" x 6" x 17'	
7.	1" x 10" x 12'	
8.	1" x 4 " x 26'	
9.	1" x 8" x 35'	
10.	1" x 12" x 18'	
11.	2" x 6" x 18'	
12.	2" x 10" x 31'	
13.	2" x 4" x 23'	
14.	3" x 8" x 9'	
15.	4" x 12" x 11'	
16.	6" x 6" x 13'	
17.	2" x 10" x 14'	
18.	$1\frac{1}{4}$" x 4" x 9'	
19.	$3\frac{3}{4}$" x 8" x 8'	
20.	$4\frac{1}{4}$" x 12' x 6'	

ESSEX BOARD MEASURE TABLE



1	2	3	4	5	6	7	8
	1-4	2	2-8	3-4	4	4-8	5-4
	1-6	2-3	3	3-9	4-6	5-3	6
	1-8	2-6	3-4	4-2	5	5-10	6-8
	1-10	2-9	3-8	4-7	5-6	6-5	7-4
	2-2	3-3	4-4	5-5	6-6	7-7	8-8
	2-4	3-6	4-8	5-10	7	8-2	9-4
	2-6	3-9	5	6-3	7-6	8-9	10

9	10	11	12	13	14	15	16
6	6-8	7-4	8	8-8	9-4	10	10-8
6-9	7-6	8-3	9	9-9	10-6	11-3	12
7-6	8-4	9-2	10	10-10	11-8	12-6	13-4
8-3	9-2	10-1	11	11-11	12-10	13-9	14-8
9-9	10-10	11-11	13	14-1	15-2	16-3	17-4
10-6	11-8	12-10	14	15-2	16-4	17-6	18-8
11-3	12-6	13-9	15	16-3	17-6	18-9	20

17	18	19	20	21	22	23	
11-4	12	12-8	13-4	14	14-8	15-4	16
12-9	13-6	14-3	15	15-9	16-6	17-3	18
14-2	15	15-10	16-8	17-6	18-4	19-2	20
15-7	16-6	17-5	18-4	19-3	20-2	21-1	22
18-5	19-6	20-7	21-8	22-9	23-10	24-11	26
19-10	21	22-2	23-4	24-6	25-8	26-10	28
21-3	22-6	23-9	25	26-3	27-6	28-9	30

I. Activity: The Brace Measure Table

II. Objective: The student should be able to:

Use the brace measurement table to find the length of braces

III. Background Information:

A. The brace measure table appears on the back of the tongue of the carpenter's square and gives the lengths of braces that are commonly used. To find the lengths of braces it is necessary first to know the length of two sides of a square.

B. On the brace table, note the same figures appearing one above another. These represent the sides of the square. The figure to the right and between them represent the length of a brace. For example, $\frac{24}{24}\,33\frac{94}{}$ means that a square having a side of 24" or 24' long has a diagonal (brace) 33.94" or 33.94' long.

IV. Materials:

A. Transparency entitled, "The Brace Measure Table"

B. Work sheet entitled, "Brace Yourself"

C. Chart entitled, "The Brace Measure Table"

V. Suggested Procedure:

A. Show the students the brace table using transparency entitled, "The Brace Measure Table."

B. Show the students where the brace table is located by holding up a carpenter's square.

C. Show the students how to read the brace table using transparency and example problem given in the background.

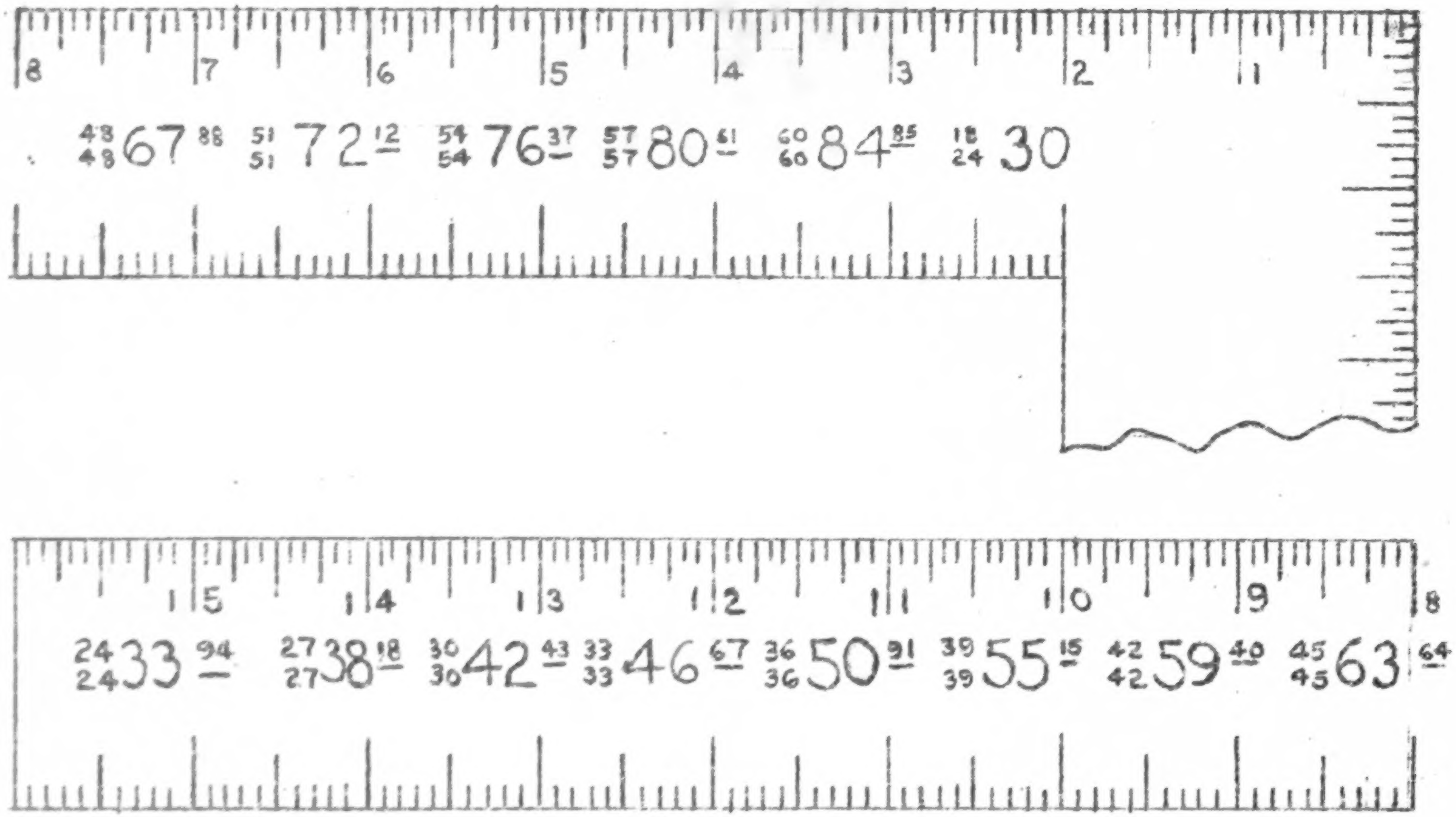
D. Hand out work sheet and have students complete it.

BRACE YOURSELF

Directions: Compute the length of the following braces using your table.

Side of a Square	Length of Brace
1. 24"	
2. 30"	
3. 42"	
4. 51'	
5. 36"	
6. 27"	
7. 60"	
8. 54"	
9. 45"	
10. 33"	
11. 39"	
12. 48"	
13. 42"	
14. A rectangle with a width of 18" and a length of 24"	

THE BRACE MEASURE TABLE


8 7 6 5 4 3 2 1
48 48 67.88 51 51 72.12 54 54 76.37 57 57 80.61 60 60 84.85 18 24 30
15 14 13 12 11 10 9 8
24 24 33.94 27 27 38.18 30 30 42.43 33 33 46.67 36 36 50.91 39 39 55.15 42 42 59.40 45 45 63.64

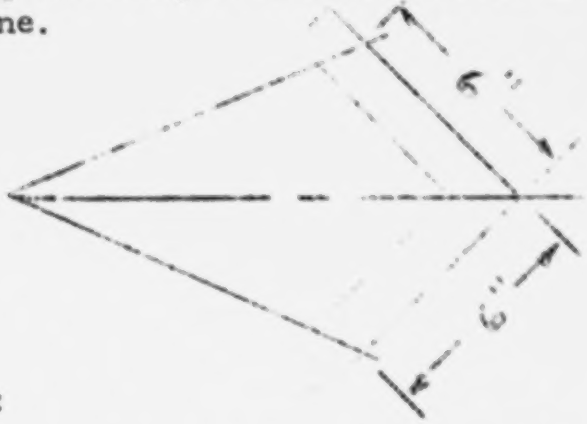
I. Activity: To Bisect an Angle

II. Objective: The student should be able to:

Bisect an angle using a carpenter's square

III. Background Information:

To bisect an angle with a carpenter's square, measure the same distance on each side of the angle from the vertex. Place the square so that the body and tongue have the same measurement as shown in the figure below. The vertex or heel of the square will then be on the bisector of the angle. Mark this point and join it to the vertex of the angle with a straight line.



IV. Materials:

A. Several carpenter's squares for student use

B. A six-inch scale for each student

C. A compass for each student

D. Work sheet, with angles drawn on it to be bisected, for each student

V. Suggested Procedure:

A. Hand out six-inch scales.

B. Have students get out sheet of paper.

C. Show students how to bisect an angle with compass and straightedge.

D. Hand out work sheet and have student bisect three angles using this method.

E. Using six-inch scale and a sheet of paper, have students mark off eighth inch divisions along adjacent edges of paper starting from the same corner. This will be their carpenter's square.

F. Show them how to bisect an angle using a carpenter's square.

G. Show them how to bisect an angle using their carpenter's square.

H. Have students complete work sheet.

I. A good follow-up activity for bisecting an angle would be have the students (in groups) bisect angles on the chalkboard using a carpenter's square.

I. Activity: The Octagon Scale

II. Objective: The student should be able to:

Use an octagon scale to construct an octagon

III. Materials:

A. Transparency entitled, "The Octagon Scale"

B. Chart entitled, "The Octagon Scale"

C. Compass or divider for each student

IV. Suggested Procedure:

A. Have the students draw a 6" square on a sheet of paper while you draw it on a transparency.

B. Locate the center of each of the four sides of the square.

C. Show the students the octagon scale using transparency and where it is located on the carpenter's square. The octagon scale appears on the face side of the tongue. It consists of a number of divisions marked along center of the tongue.

D. Hand out student copies of the octagon scale.

E. Set a pair of dividers or compasses to a width of 6 spaces on the octagon scale.

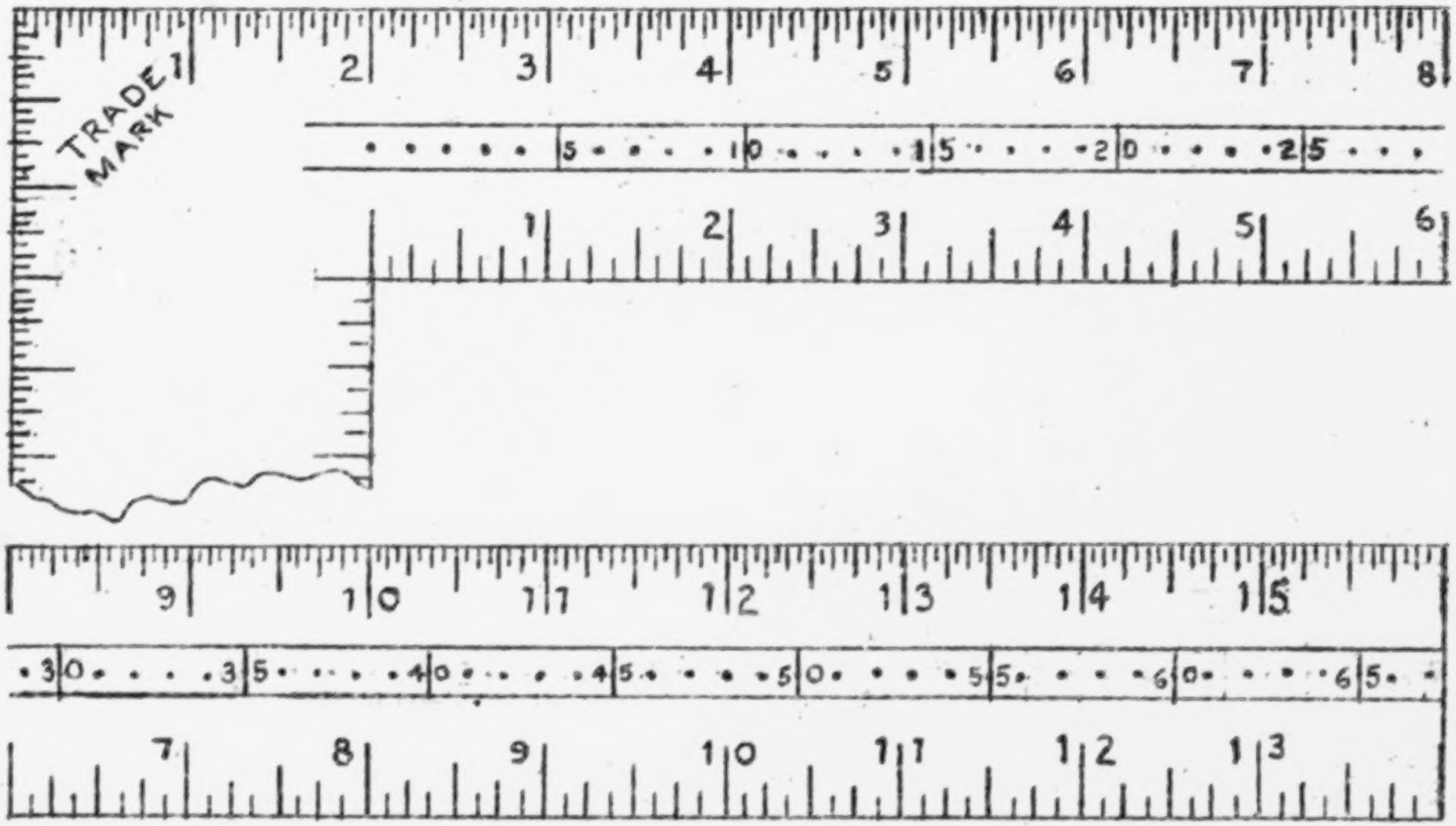
F. Transfer this width to each side of each center point on the 6" square and mark it.

G. Connect these marks with straight lines and you have an octagon.

H. Have students draw 1", 4", 6", 8", and 12" squares and construct octagons out of them.

I. A good follow up activity would be to have students construct octagons on the board using compass and carpenter's square.

THE OCTAGON SCALE


TRADE MARK
1 2 3 4 5 6 7 8
5 10 15 20 25
1 2 3 4 5 6
9 10 11 12 13 14 15
30 35 40 45 50 55 60 65
7 8 9 10 11 12 13

I. Activity: A Mud Calculator

II. Objectives: The student should be able to:

   A. Find the number of cubic yards of concrete in a given figure by formula

   B. Find the number of cubic yards of concrete in a given figure using a concrete calculator

III. Background Information:

   This activity should follow or be related to Chapter 13 in the textbook, "Cubic Measure."

IV. Materials:

   A. Concrete calculator for each student

   B. Textbook

   C. Transparency entitled, "Concrete Calculator"

   D. Work sheet for each student entitled, "A Mud Calculator"

V. Suggested Procedure:

   A. Review or work problems in text on page 239, #7, 9; page 248, #7, 8; and page 250, #13. These problems all involve concrete.

   B. Work several example problems such as the following:

      1. You are building a driveway 8' wide 20' long and 5" thick. How much concrete will it take?

      2. You are building a porch 15' wide 20' long and 4" thick. How much concrete will you need?

      3. These problems all involve the formula V = l x w x h.

   C. Ask "Do you think a builder would work these problems the same way?

   D. Show the student a concrete calculator and distribute them to the class.

E. Use the transparency entitled, "Concrete Calculator" to show students how it works.

  1. Take first example problem:

    a. locate the thickness (5") on "A" scale

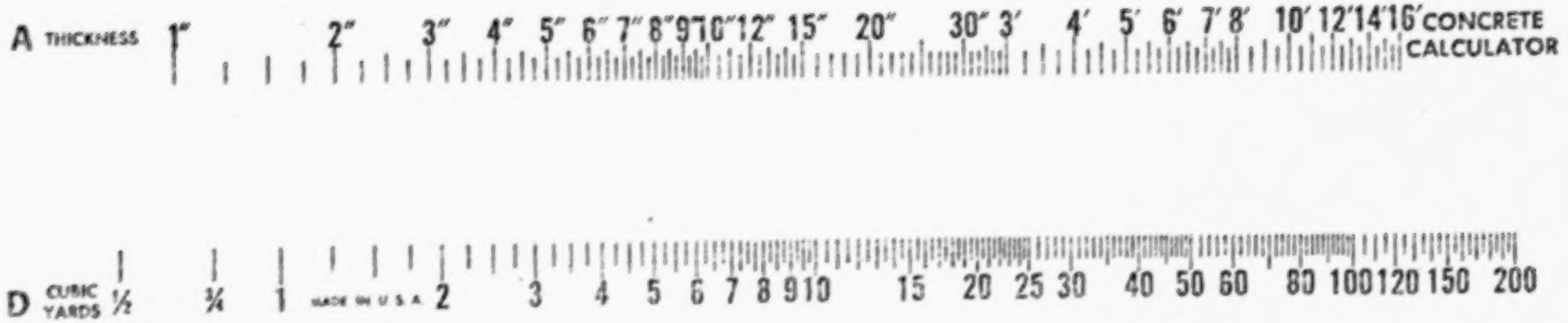
    b. slide the middle until the width (8') on the "B" scale coincides with the (5") on "A" scale

    c. Locate the length (20') on the "C" scale and the answer is about 2 $\frac{1}{2}$ cubic yards

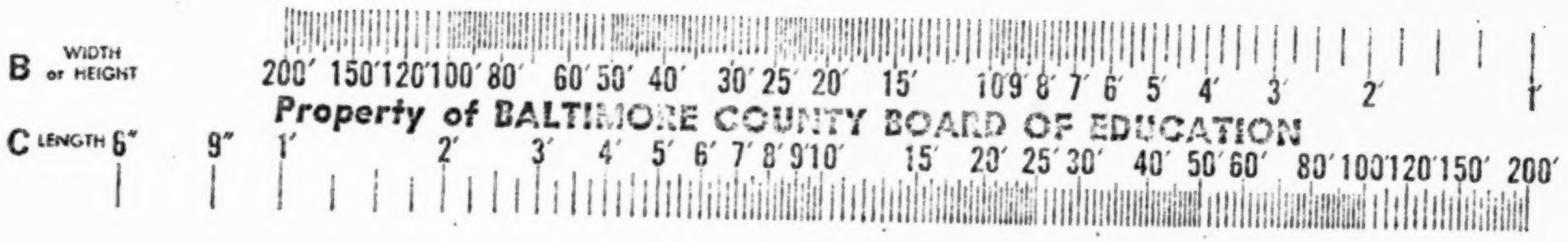
  2. Use the transparency to demonstrate the solution to the second example problem.

F. Hand out work sheet entitled, "A Mud Calculator."

CONCRETE CALCULATOR


A THICKNESS
1" 2" 3" 4" 5" 6" 7" 8" 9" 10" 12" 15" 20" 30" 3' 4' 5' 6' 7' 8' 10' 12' 14' 16'
CONCRETE CALCULATOR
D CUBIC YARDS
½ ¾ 1 2 3 4 5 6 7 8 9 10 15 20 25 30 40 50 60 80 100 120 150 200
MADE IN U.S.A.

CONCRETE CALCULATOR


B WIDTH or HEIGHT
200′ 150′ 120′ 100′ 80′ 60′ 50′ 40′ 30′ 25′ 20′ 15′ 10′ 9′ 8′ 7′ 6′ 5′ 4′ 3′ 2′ 1′
Property of BALTIMORE COUNTY BOARD OF EDUCATION
C LENGTH 6″ 9″ 1′ 2′ 3′ 4′ 5′ 6′ 7′ 8′ 9′ 10′ 15′ 20′ 25′ 30′ 40′ 50′ 60′ 80′ 100′ 120′ 150′ 200′

A MUD CALCULATOR

Directions: You are a cement contractor. One of your responsibilities is to calculate the amount of cement necessary for driveways, proches, sidewalks, and patios. If cement costs $15.40 a cubic yard, calculate the cost of cement for each of the following jobs.

Dimensions	Number of Cubic Yards Needed	Cost for Job
1. 2" x 3' x 1'		
2. 3" x 10' x 4'		
3. 4" x 8' x 9'		
4. 5" x 15' x 15'		
5. 3" x 24' x 30'		
6. 5" x 90' x 41'		
7. 4" x 62' x 52'		
8. 2" x 12' x 72'		
9. 3" x $3\frac{1}{2}$' x $8\frac{1}{2}$'		
10. 5" x 35' x 17'		

I. Activity: Concrete Block Calculators

II. Objectives: The student should be able to:

- A. Find the number of concrete blocks in a wall using an area formula
- B. Find the number of concrete blocks in a wall using a concrete calculator

III. Background Information:

This activity should follow the section in the textbook entitled, "Brickwork" (14. 6) pages 273-280. The book emphasizes finding the number of bricks and the cost of the bricks. Also there are a few problems on concrete blocks.

IV. Materials:

- A. Concrete calculator for each student
- B. Textbook
- C. Transparency entitled, "Concrete Calculator"
- D. Work sheet for each student entitled, "Concrete Blocks"

V. Suggested Procedure:

A. Review how to find number of concrete blocks in a wall. Use example #4 on page 278 in textbook. Work example problem on page 280 #9. Work each of the following examples:

1. A masonry wall to be built out of concrete blocks is 8' high and 10' long. Find the number of concrete blocks if the dimensions of the block are $15\frac{3}{4}$" long by $7\frac{3}{4}$" high by $7\frac{3}{4}$" wide.
2. A Masonry wall to be built out of concrete blocks is 10' high and 20' long. Find the number of concrete blocks if the dimensions of the block are $15\frac{3}{4}$" long by $7\frac{3}{4}$" high by $7\frac{3}{4}$" wide.

B. Hand out concrete calculator.

C. Use transparency entitled, "Concrete Calculator," to show students how to work the first example problem.

  1. Locate the 8' on "B" scale, then slide the middle until it coincides with the 3' mark on the "A" scale.

  2. Locate the 10' on the "C" scale. This will coincide with the answer on the "D" scale. The answer is 88 blocks (not 8.8 blocks). The "D" scale is actually $\frac{1}{10}$ of the required number. Therefore, all answers on "D" scale must be multiplied by ten.

  3. If the wall area is over 1000 square feet, then the answer on the "D" scale must be multiplied by 100. For example, a masonry wall is 100' long and 20' high. Find the number of concrete blocks in the wall.

     a. If you attempt to work the problem using the 20' and 100' you will discover that the answer is off the "D" scale.

     b. To correct this situation, we will divide "B" or "C" scale by ten.

     c. Locate 2' on "B" scale, then slide the middle until it coincides with the 3' mark on the "A" scale.

     d. Locate the 100' on the "C" scale, this will coincide with the answer on the "D" scale. The answer is about 2250 blocks (not 22.5 or 225). The "D" scale is actually $\frac{1}{100}$ of the required number.

CONCRETE BLOCKS

Directions: You are a block layer. You are responsible for calculating the number of blocks for walls and the cost. Find the cost for each of the following jobs if the blocks cost $0.22 a piece.

Job Size of Walls	Number of Blocks	Cost of Job
1. 4' x 20'		
2. 8' x 60'		
3. 6' x 70'		
4. 7' x 52'		
5. 12' x 15'		
6. 10' x 35'		
7. 9' x 47'		
8. 14' x 38'		
9. 17' x 21'		
10. 20' x 16'		
11. 60' x 10'		
12. 14' x 17'		
13. 30' x 29'		
14. 40' x 56'		
15. 22' x 50'		

I. Topic: Installing a Driveway

II. Objectives: The student should be able to:

A. Explain the process of bidding that contractors use to obtain jobs

B. Divide an irregular shape into shapes for which the area can be found

C. Change a measure in inches to feet using a scale of $\frac{1}{16}$ inch equals 1 foot

III. Background Information:

Many contractors must prepare rather accurate estimates of jobs for which they wish to be hired. If their bid is lower than those of their competitors, they will probably be hired. This activity is geared to the process of bidding. The first of the three work sheets, "What Do You Bid?," and the accompanying instruction sheet should describe the approach. The results of each student will be different, therefore, the task of checking their work will not be feasible. (See Suggested Procedure) The second work sheet, "Will Your Dollars Make Sense?," should result in more uniform answers, depending upon the degree of accuracy of the students' measurements. The third work sheet is provided as an exercise where all computations should be the same as all dimensions are given.

IV. Materials:

A. Student work sheets entitled:

1. "What Do You Bid?" (and accompanying instruction sheet)
2. "Will Your Dollars Make Sense?"
3. "All Bids Alike"

B. Student ruler

V. Suggested Procedure:

A. Distribute the work sheet, "What Do You Bid?" and the student instruction sheet.

B. Discuss the process of bidding and go over the instruction sheet. Try to create an atmosphere of competition among the students. Inform them that they may want to challenge someone's bid which is lower than their own.

C. After the students complete their driveway designs and compute their bid, allow time for them to compare and challenge each other.

D. Continue at your own comfortable pace in assigning the remaining two work sheets.

Solution to "All Bids Alike"

Area: 1435.5

Cost of asphalt at 20¢ per square foot	$287.10
Cost of crusher run at 3¢ per square foot	43.07

WHAT DO YOU BID?

The accompanying diagram shows a bird's eye view of a house. You are looking down on it. Notice the road at the bottom of the picture. Suppose you are the owner of a small asphalt company which specializes in installing driveways. Mr. Balamer, the owner of the house, wants you to estimate the cost of a driveway. He has talked to other companies and will probably hire the one who names or bids the lowest price.

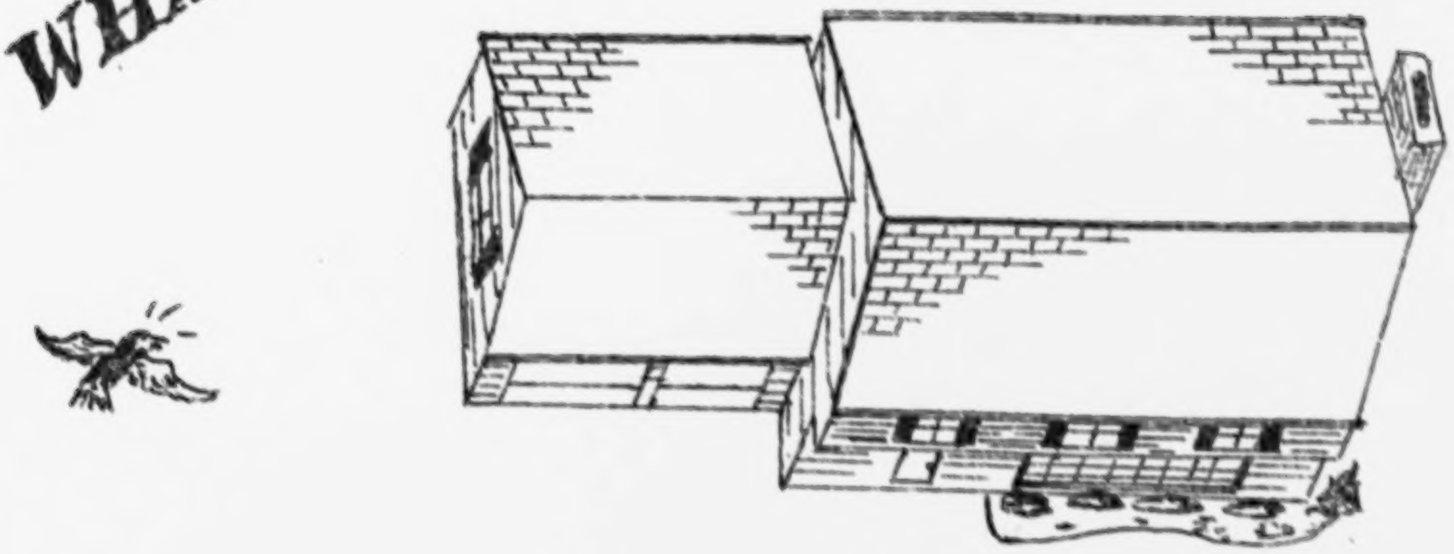
What do you bid if:

1. The front of the garage is 90 feet from the road
2. The garage is 24 feet across the front
3. Mr. Balamer wants room enough to turn around in his driveway:
   a. the greatest length of a vehicle to use the driveway to be 20'
   b. consider a maximum turning radius of 18 feet
4. The cost of preparing and spreading a bed of crusher run (a gravel like base for the asphalt) is 3¢ a square foot
5. The cost of laying the asphalt is 20¢ a square foot. (These prices include the cost of the materials.)

Here is what you need to do:

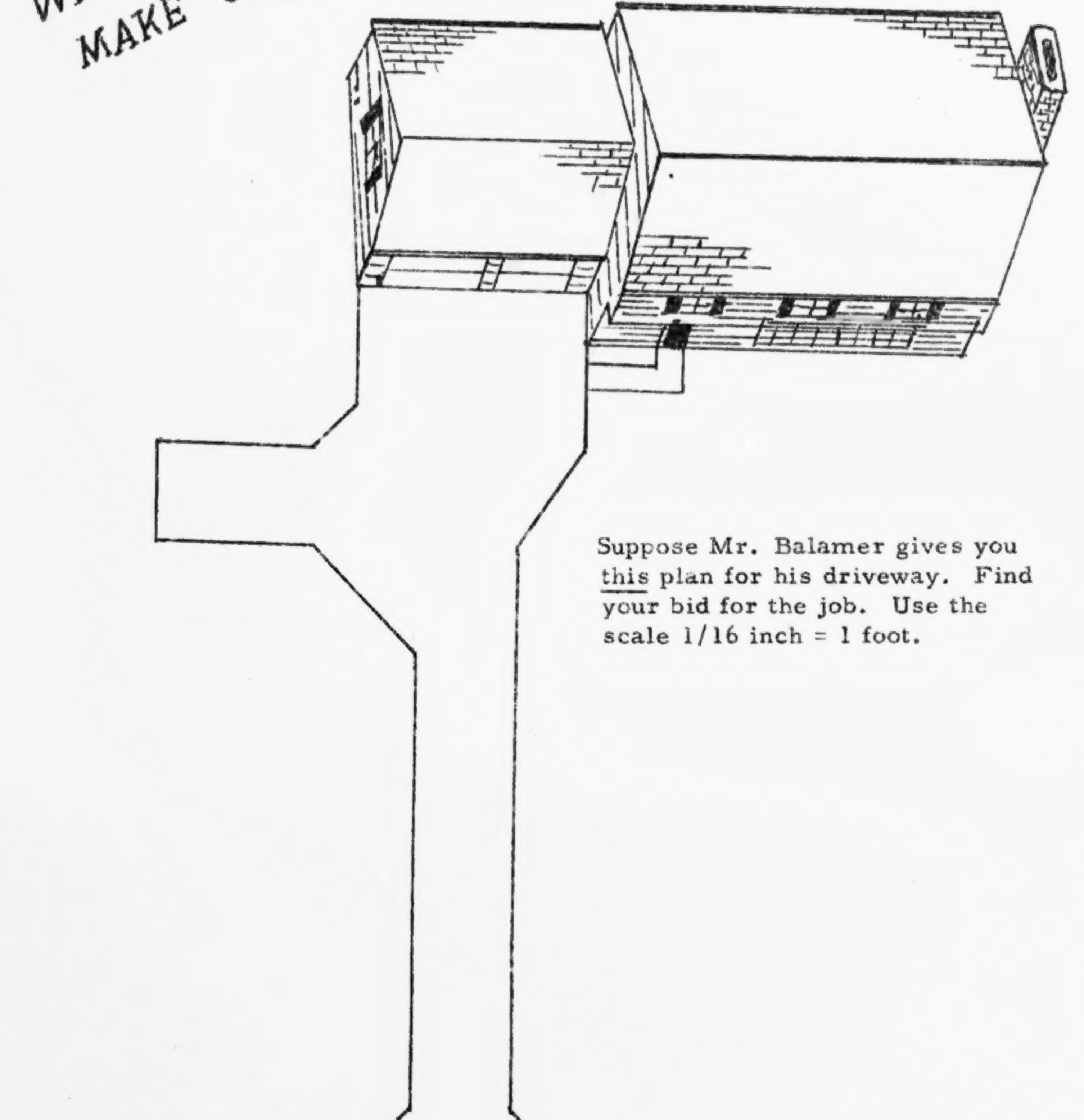
1. Draw your plan for Mr. Balamer's driveway on the sheet with the picture of the house.
2. Find the total area of the driveway by breaking your diagram into sections for which you can calculate the area. If you care to use a scale drawing, use the scale of $\frac{1}{16}$ inch = 1 foot.
3. Determine the cost.
4. MAKE SURE you present your calculations neatly so that Mr. Balamer will clearly understand. Your neatness on this will indicate somewhat the type of work you do on driveways!

WHAT DO YOU BID ?



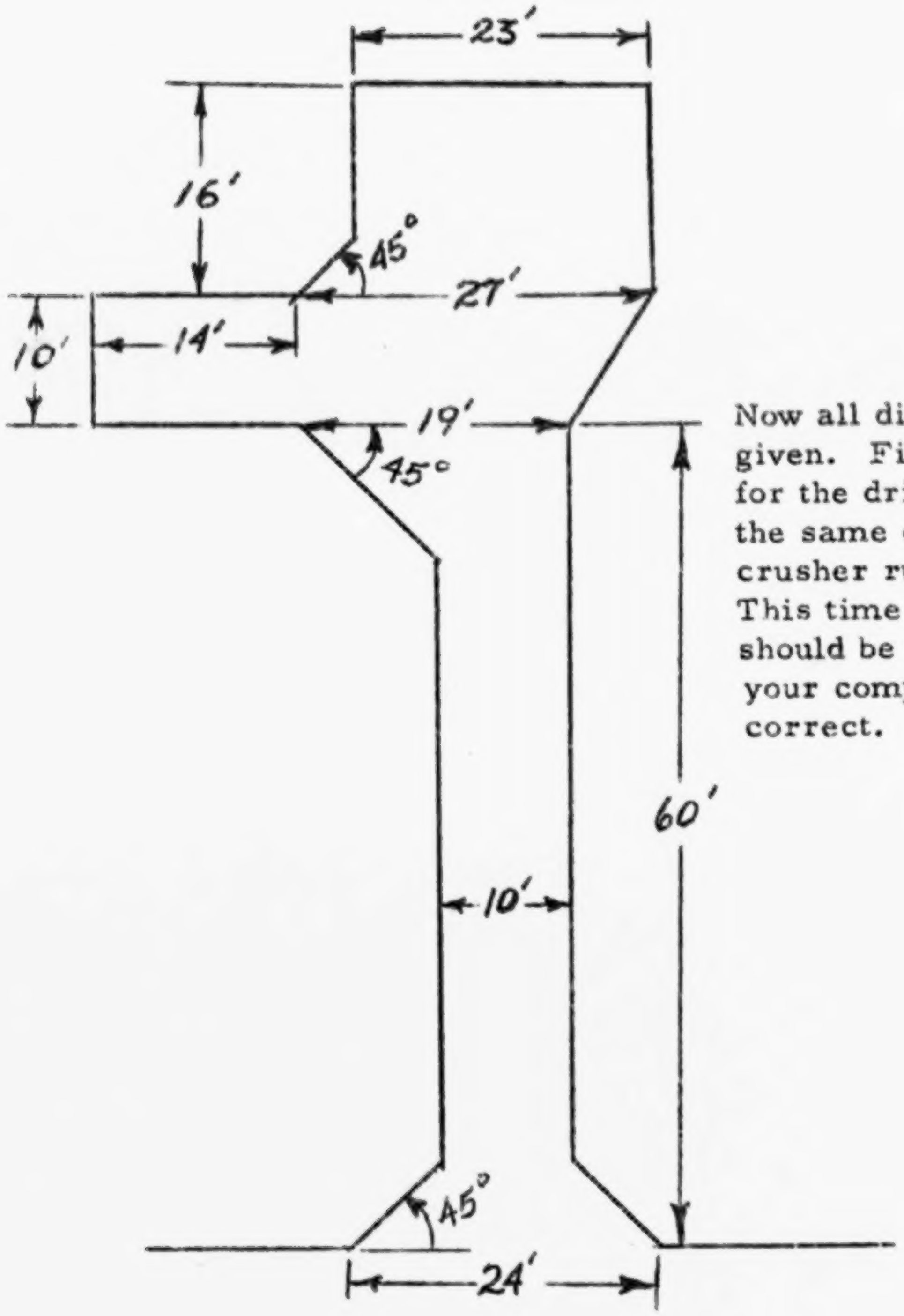
BALMER BLVD.

WILL YOUR DOLLAR$ MAKE SENSE ?



Suppose Mr. Balamer gives you this plan for his driveway. Find your bid for the job. Use the scale 1/16 inch = 1 foot.

ALL BIDS ALIKE !


23'
16'
45°
27'
10'
14'
19'
45°
60'
10'
45°
24'

Now all dimensions are given. Find the cost for the driveway using the same costs for crusher run and asphalt. This time all bids should be the same if your computation is correct.

I. Topic: Inside and Outside Diameter for Pipe and Tubing

II. Objective: The student should be able to:

Apply the rules for using calipers and steel scales

III. Background Information:

A. Pipe is the older established material used in plumbing and has the following characteristics:

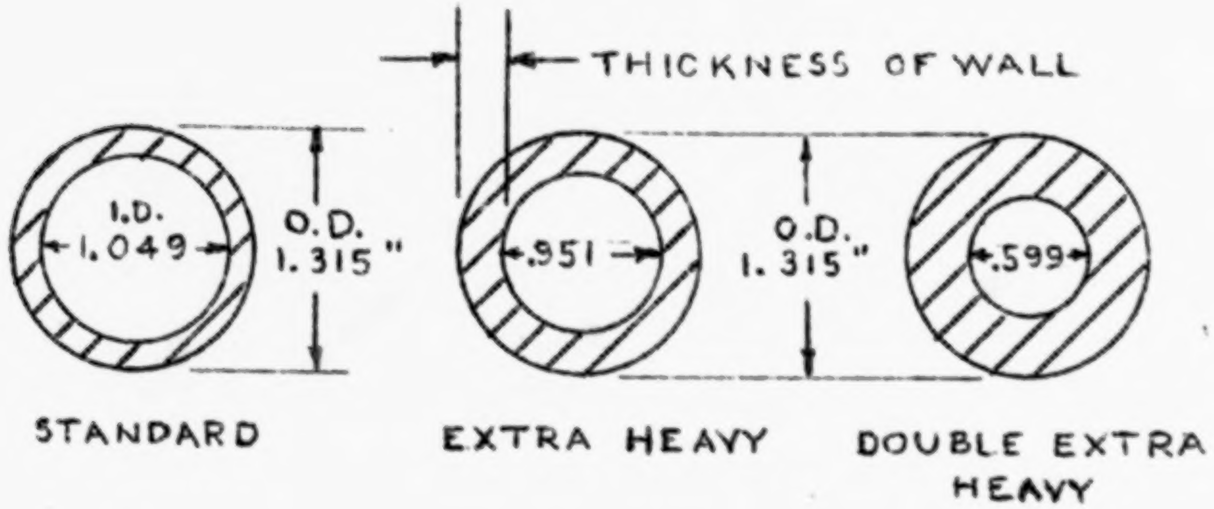
1. It is made of wrought iron, wrought steel, cast iron, copper, brass, or lead

2. It is made in three weights which correspond to wall thickness--standard, extra-heavy, and double extra-heavy based on water pressure strengths

3. Water pressure determines weight of pipe used and most plumbing is done with standard pipe

4. Nominal or name size is based on inside diameter, up to 12". Above 12" the size is given for outside diameter and wall thickness is specified

5. All weights of one inch nominal size pipe have the same outside diameter so that the same threading die may be used for all. Nominal size is based on inside diameter, but not necessarily the same. Walls have become thinner over the years for some smaller sizes.



6. Pipe is characteristically inflexible and pipe fittings or cuts and welds are required. A variety of tees, elbows, unions, and other fittings are threaded to fasten to the pipe and allow for most situations

7. Pipes generally come in 20 foot lengths and are threaded unless specified otherwise

B. Tubing is a product of modern technology and is an improvement on pipe in many instances. The advantages and characteristics of tubing include:

1. It is light in weight and, therefore, easier to transport in quantity and work with

2. It is flexible and can be carried in rolls of 50 feet and more. Flexibility allows simple bends of some tubing, and, therefore, minimizes the use of fittings.

3. Joints are sweat fittings (soldering process)

4. Size is the outside diameter measure

5. Tubing comes in a variety of shapes (i. e. square, hexagonal, irregular) some of which have been custom made

IV. Materials:

A. Inside and outside caliper kit (with pipe and tubing samples)

B. Inside and outside calipers

C. Steel scales

D. Chalkboard compass

V. Suggested Procedure:

A. Using the background information and the pipe and tubing samples, give the class a brief orientation. Define the terms and point out on the samples:
Inside Diameter - ID
Outside Diameter - OD
Wall Thickness - T
Double Wall Thickness - 2T

B. Have students sketch a cross section and label with the above letters. Have one drawn on the chalkboard as a reference and a check.

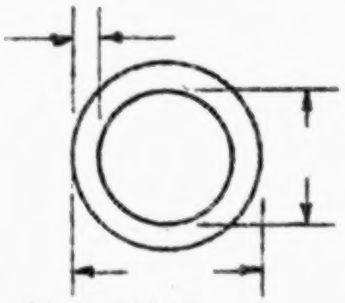
C. Tell students that they will first find inside diameter without measuring. Later, inside calipers will be passed out to measure inside diameter. (The relationship will be clear to the student when direct and indirect measurement are compared.)

D. Pass out the outside calipers and steel scales. Distribute the pipe and tubing sections from the inside-outside caliper kit. (The inside caliper will be used as a check later.)

E. Pass out the work sheet entitled, "Inside and Outside Diameter." Directions are explicit so that students should be able to complete the sheet with a minimum of questions. It will probably be necessary to collect all items and pass them out again the next day to finish measurements.

VI. Suggested Evaluation:

A. Label the drawing with T, OD, ID in the proper places.



B. Fill out the chart for the various dimensions.

Item No.	OD	ID	2T	T
1	2"	$1\frac{3}{4}$"		
2	1.500"			.125"
3	.750"		.125"	
4		1"	.250"	
5		1.250"		$\frac{1}{16}$"

INSIDE AND OUTSIDE DIAMETER

1. Fill out columns A, B, C from measurements.
2. Fill out columns D, E, F from the information in columns A, B, C.

A	B	C	D	E	F	G
ITEM NUMBER	OD	T	T + T (2T)	OD-2T (ID)	Name Size	ID (Measured)

3. Column G should be filled out from inside caliper measurements.

I. Activity: How Many Yards in a Footing?

II. Objectives: The student should be able to:

- A. Describe a "footing"
- B. Use the concrete calculator to find the number of yards of concrete necessary for footing and a specific slab

III. Background Information:

Students should have a basic knowledge of the determination of the volume of rectangular prisms. This activity is an exercise designed as an application of the concrete calculator. Reference is paid to its use in the slide tape, "Man on the Job" interview with Mr. Thomas Gentry of the Churchville Construction Company. Although not necessary, this may be considered as a motivation for this lesson.

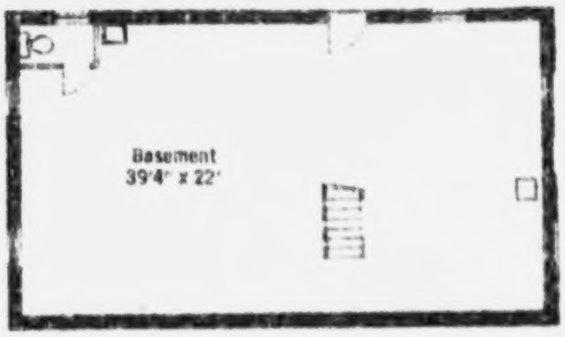
IV. Materials:

- A. Student work sheet entitled, "How Many Yards in a Footing?"
- B. Concrete calculator

V. Suggested Procedure:

- A. Distribute the work sheet entitled, "How Many Yards in a Footing?"
- B. Discuss the concept of footing with the class.
- C. Review the procedure for using the concrete calculator.
- D. Have students complete the work sheet.

HOW MANY YARDS IN A FOOTING?



In building the house shown above, first the basement is dug and then around the edge of the bottom of the basement a trench is dug. Concrete is poured into this trench. It is this bedding of concrete which must support the house. This bedding is called footing.

1. Use the concrete calculator to find the number of yards (cubic yards) of concrete necessary to order for the footing of this basement. The footing should be 14" wide and 10" deep.
2. The owner of the house desires to install a concrete patio at the rear of the house. If this patio is to be 20 feet long, 15 feet wide, and 6 inches thick, find the number of yards of concrete that must be ordered.

HOME AND FINANCE ACTIVITIES

Home & Finance
Activities

I. Activity: Apartment Living

II. Objectives: The student should be able to:

A. State at least two reasons for the selection of an apartment as a place of living

B. Change an hourly rate of income to a weekly rate

C. State at least two disadvantages of apartment living

III. Background Information:

Many students, upon graduation and then marriage, will be considering the rental of an apartment. Some may presently live or have lived in an apartment, so the possibilities for class discussion on this topic are good. Current newspapers will offer a wealth of information concerning local rental fees and conditions of rental.

A large part of this lesson deals with the ability to afford current rental fees. If the student is now made aware of the cost of living in a realistic fashion, this may better motivate his vocational endeavors.

IV. Materials:

A. Current newspaper ads (Sunday Real Estate section) for apartments.

B. Copies of the title sheet for the whole unit, picturing a person looking into the future and faced with the problem of the selection of a home.

C. Copies of the student work sheet entitled, "An Apartment, What Type?"

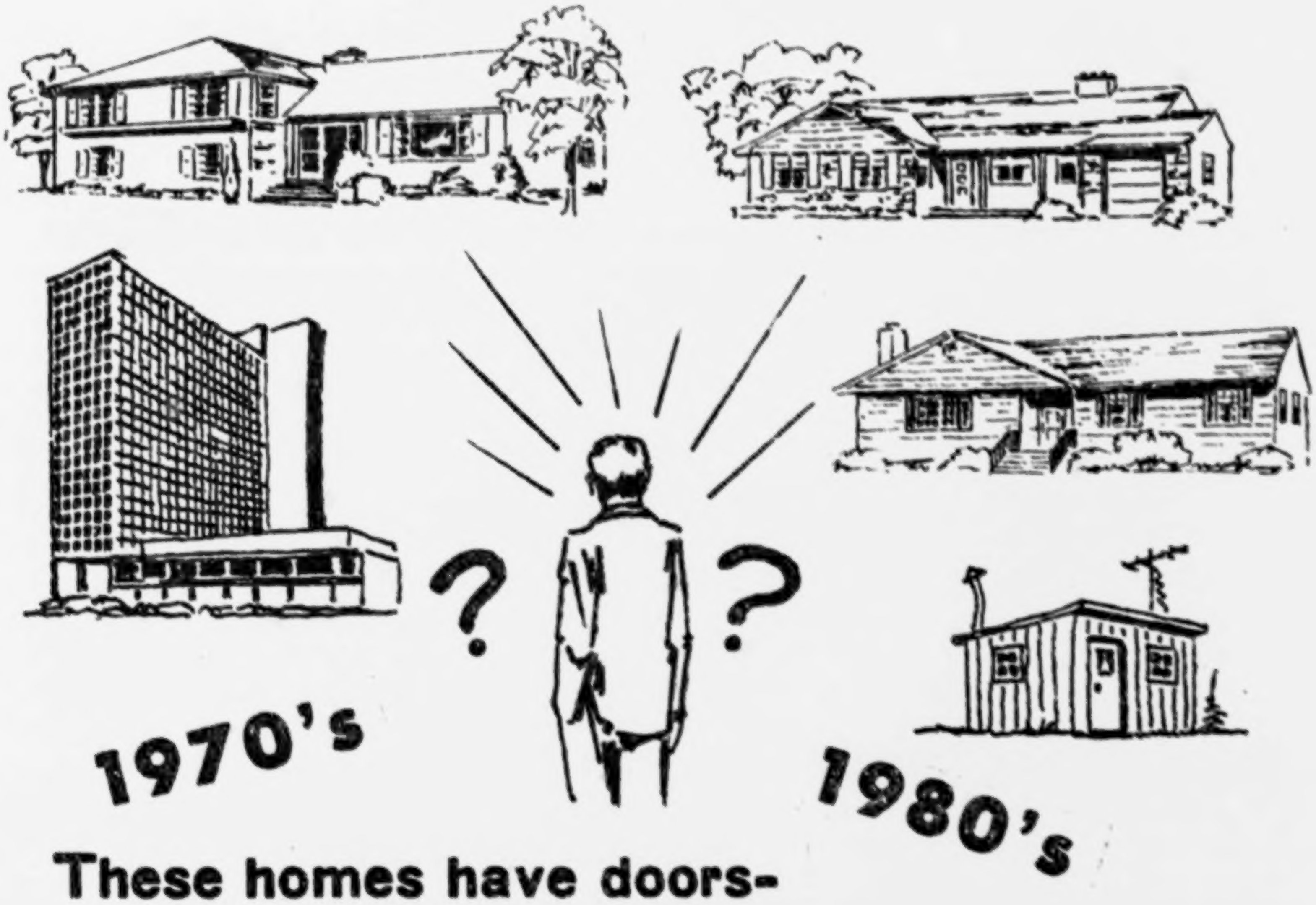
V. Suggested Procedure:

A. In order to stimulate discussion in general on the fact that most students will be faced with the problem of a place to live, distribute the title sheet for the whole unit. Discuss the questions appearing on the sheet.

B. Narrow the discussion to apartment living and distribute the work sheet, "An Apartment, What Type?"

C. IMPORTANT: This work sheet is not a "pass-out-and-do-it" work sheet. It is important that the teacher becomes familiar with the contents of the sheet before class. It may be advisable to read through the various thoughts and questions, one at a time, with the students and pause to allow them to fill in reasons, statements, or perform calculations where they are called for.

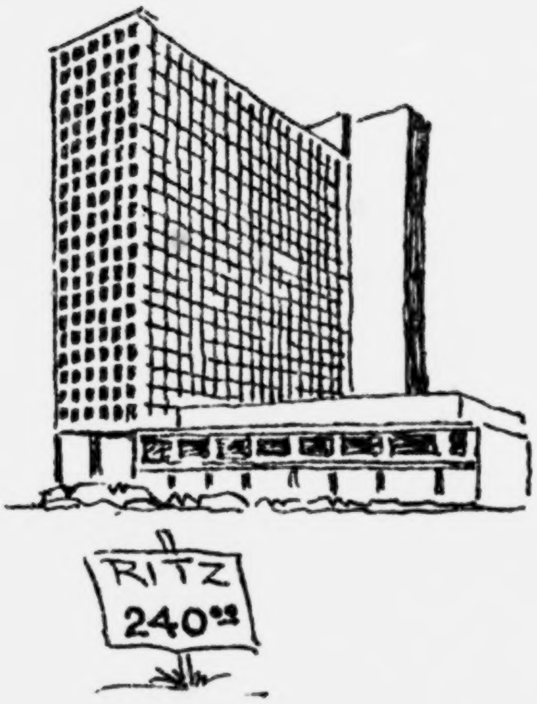
D. As a follow up to this, have students bring in newspaper clippings or ads from their newspapers. Place some on the bulletin board.



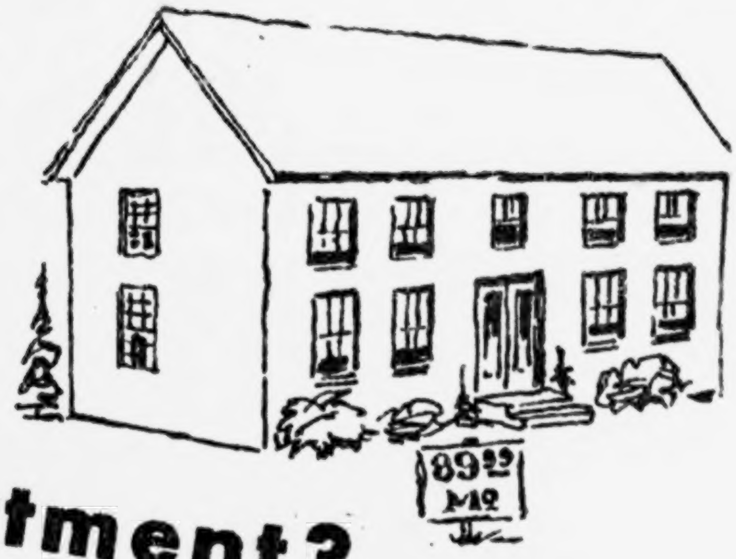
These homes have doors-
The doors have locks-
The locks need keys-
When will you have your key?
Which door would you like to open?

During the '70s and '80s you will be considering a place to call your home.

Do you know what to expect?
Do you know about the various styles of homes?
How much do they cost?
Will you be able to afford what you want?
What can you learn now to prepare for your home?
Would an apartment be better for you?



An Apartment? what type?



Pictured on the left above is a "high-rise" apartment. Why do you think this is called a "high-rise?" ____________________________

____

On the right above is a smaller apartment dwelling. In dwellings of this nature, one outside entrance may lead to four separate apartments.

The rental fee in a high rise is usually higher than that for smaller groupings. List several reasons why this might be true. ____________

____

____

____

You may choose to live in an apartment. Some reasons are:

1. You will not need a large quantity of money since you are not purchasing anything - you are just renting.
2. You may not have decided to settle permanently in that area. List some more reasons for renting an apartment.
3. ____________________________________
4. ____________________________________

Suppose you are earning $2.25 an hour. Can you afford the $89.99 rent? Many persons advise that your monthly payment for rental should not exceed one week's pay. Let's see if you can rent this apartment.

1. If you work an average 40 hour week, what is your weekly pay? ____________________________________

2. Can you rent this apartment? ______________________
3. How much would you have to earn to be able to afford the $140.00 apartment? ______________________
4. Some people may decide to try to rent an apartment with a certain rental fee even though they know their income will probably not permit it. How do you think the person renting the apartments (the landlord) guards against this? ________

____

It has already been stated why younger persons may choose to rent an apartment. Many older retired persons also find apartment living desirable. They may not care for the many responsibilities of home ownership. Which type of apartment do you think they will be most likely to choose? Why? ______________________

____

____

There are some disadvantages to living in an apartment. You have nothing to show for the money you have spent for rent. In other words you are not building any equity. If you own a home there is usually a certain amount of pride. "This is our home!" By renting you will have no pride of ownership. Some may not desire to live so close to others. List some more disadvantages? ______________________

____

Name some apartment units in your area? ______________________

____

____

Some apartments may seem to have a relatively low rental fee. This may be due to the fact that "utilities are not included." Utilities are additional expenses for gas and electricity. Examine some advertisements. See if you can determine whether or not utilities are included in the rates shown. A realistic charge for electricity for a month may be about $12. Would you expect this charge to be the same all year? Why? ______________________________

____

Would you prefer to rent an apartment where all utilities are included in the rental fee or one where you paid for utilities? Why? __________

____

____

I. Activity: So! You Want to Consider Building

II. Objectives: The student should be able to:

A. Quote reasonable rates per square foot for the construction of houses of different types

B. Calculate approximate prices of homes when dimensions are given

C. Distinguish among two story, split-level and ranch type homes

III. Background Information:

In most publications containing plans for homes, the price of the home is not given, possibly due to the fact that the price may vary in different parts of the country. However, the person contemplating building a home needs some method of approximating the cost so that he will know whether or not he can afford a particular model. In some publications an area figure is given, which usually represents the area of living space. This would not include areas of closets and area covered by room partitions. Some builders base a rough estimate on this figure and others calculate the area using the outside dimensions of the house. Regardless of the method, only an approximation is obtained since personal tastes and desires for varying quality will greatly influence the final cost. In the work sheets with this activity both methods are utilized and some problems are included which require the student to measure the outside dimensions on a scale drawing. The rates quoted are realistic for this area. These rates do include a basement (although this area does not enter into the calculation unless it is to be finished off as living space). Also assume that costs of sewage systems and drilled wells are included.

Permission to reproduce the floor plans was granted by The James Keelty Company.

IV. Materials:

A. Student work sheet entitled, "So! You Want to Consider Building"

B. Student ruler

C. 5 sketches of homes of various types

V. Suggested Procedure:

A. Distribute student work sheet entitled, "So! You Want to Consider Building"

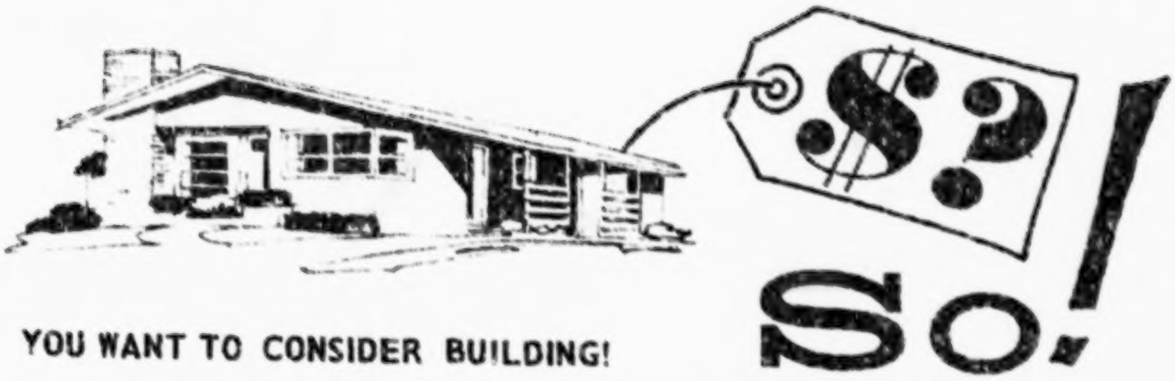
B. Use the text of the work sheet as a guide for a discussion concerning estimating construction costs. Suggest that students look in magazines at home and bring in clippings of house plans.

C. Allow students sufficient time to complete the calculations for the first three questions.

D. Go over their responses to these questions.

E. Distribute the sketch of the Salisbury home. Have students approximate the cost by just inspecting the picture of the house. Then have the students estimate the construction cost by using the dimensions on the drawing and the information at the bottom of the page.

F. Distribute the remaining sheets as time and interest allow. The sketches of the Sheffield and the Easton do not have dimensions included for the outside walls. The students should use this as a scale measurement exercise. Use the information at the bottom of each of these sheets.



YOU WANT TO CONSIDER BUILDING!

DO YOU KNOW WHAT THE PRICE TAG WILL BE?

Suppose you saw the picture of the house shown above in a magazine and you wanted an idea of the cost of building it. Rather than by just making a guess, a method of calculating the approximate cost would be helpful. A contractor (the person who will build the house) does have such a method. Using his experience drawn from the houses he has built, he will usually state a rate per square foot based on the dimensions of the house. In some publications, the area is usually supplied while in others it may be necessary to find the area using the given dimensions of the house.

Some fairly realistic rates follow. Keep in mind that these may differ from builder to builder. A lot depends upon the quality of material he uses.

Rancher	$15.00 per square foot
Split Level	$13.00 per square foot
Two-story	$12.00 per square foot

Why do you think a rancher is more expensive per square foot than a two-story?

____

____

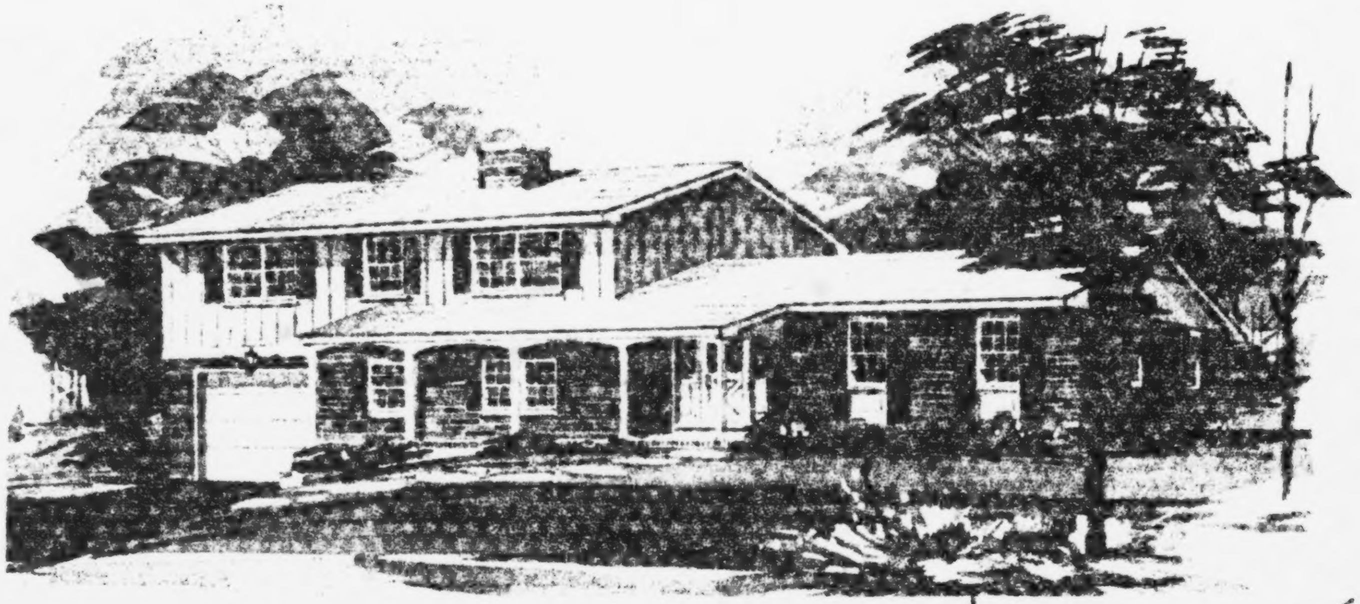
If the house pictured above is classified as a rancher and had floor area of 1980 square feet, find the cost of construction using the rates shown above.

____

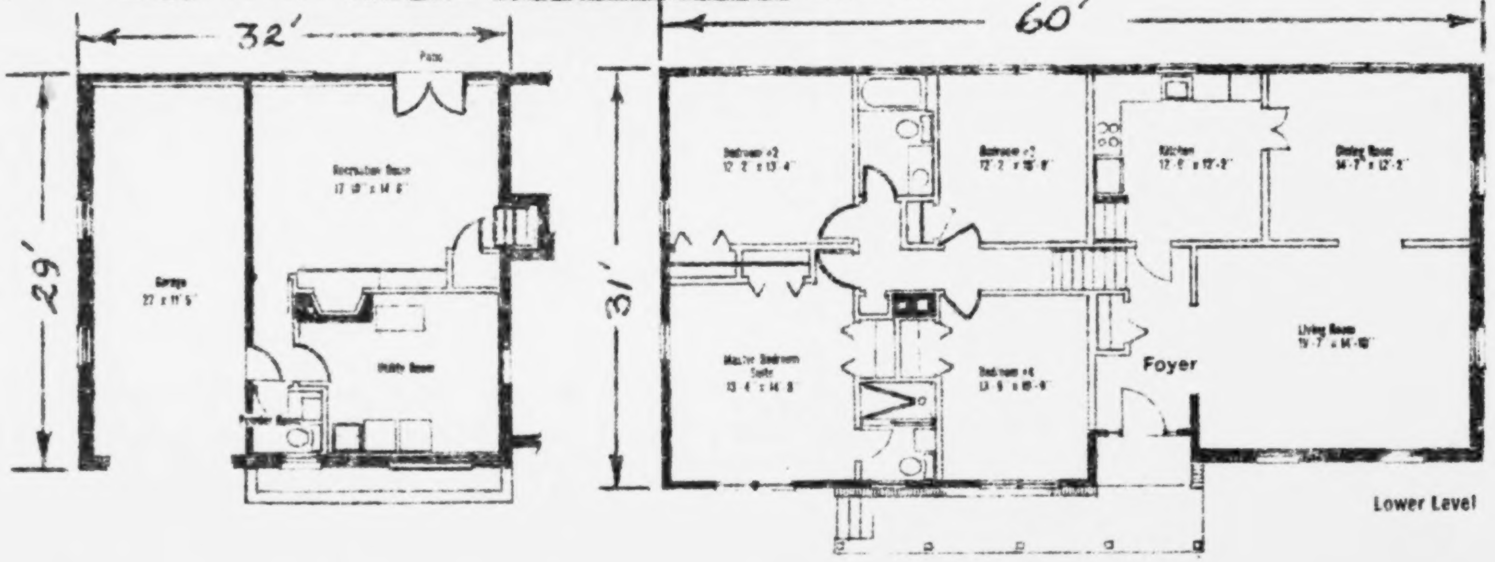
____

If a two-story has the same area as the rancher above, find the cost of constructing it. ______________________________

____



the Warwick


32'
Patio
29'
Garage
60'
31'
Kitchen
Dining Room
Living Room
Master Bedroom Suite
Foyer
Lower Level

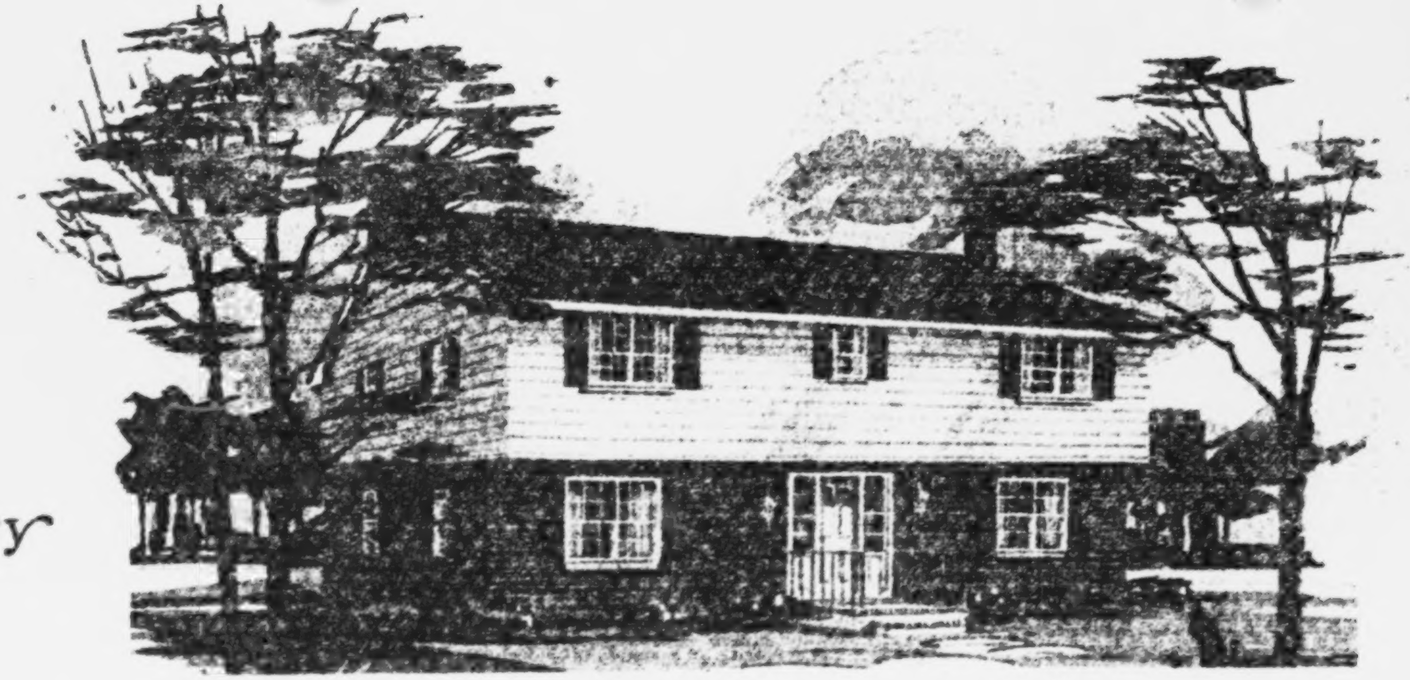
SPLIT LEVEL

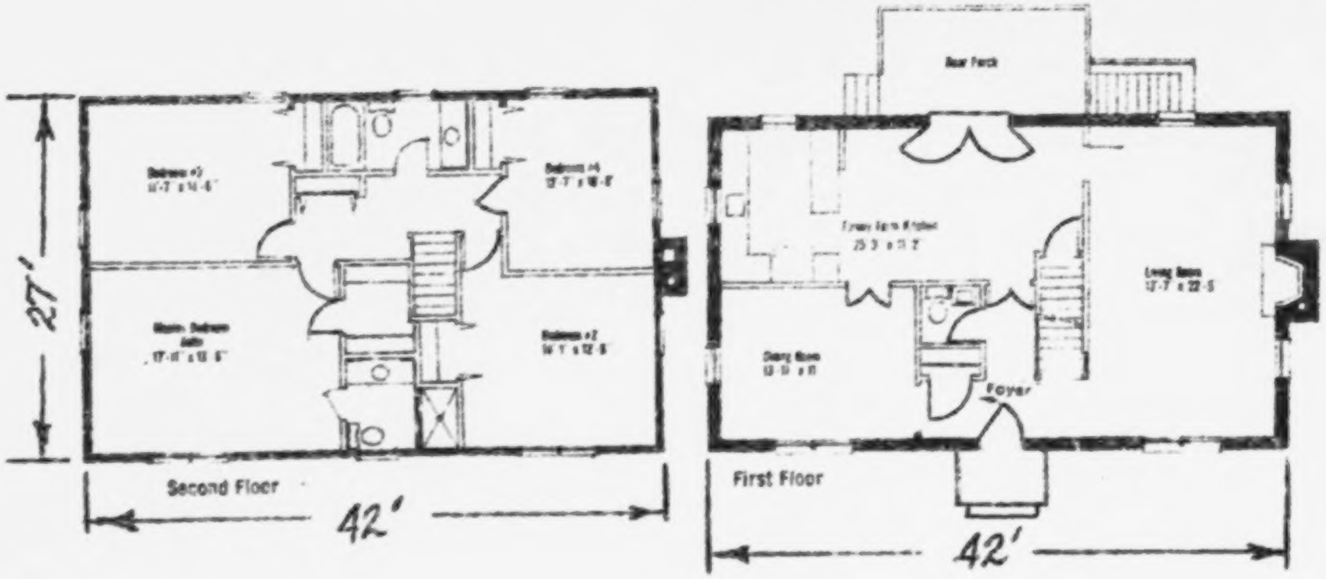
Cost--$12.50/sq. ft. middle and upper level

$ 8.00/sq. ft. lower level

Estimated cost of construction: ______________________

the Salisbury




27'
Foyer
42'
42'

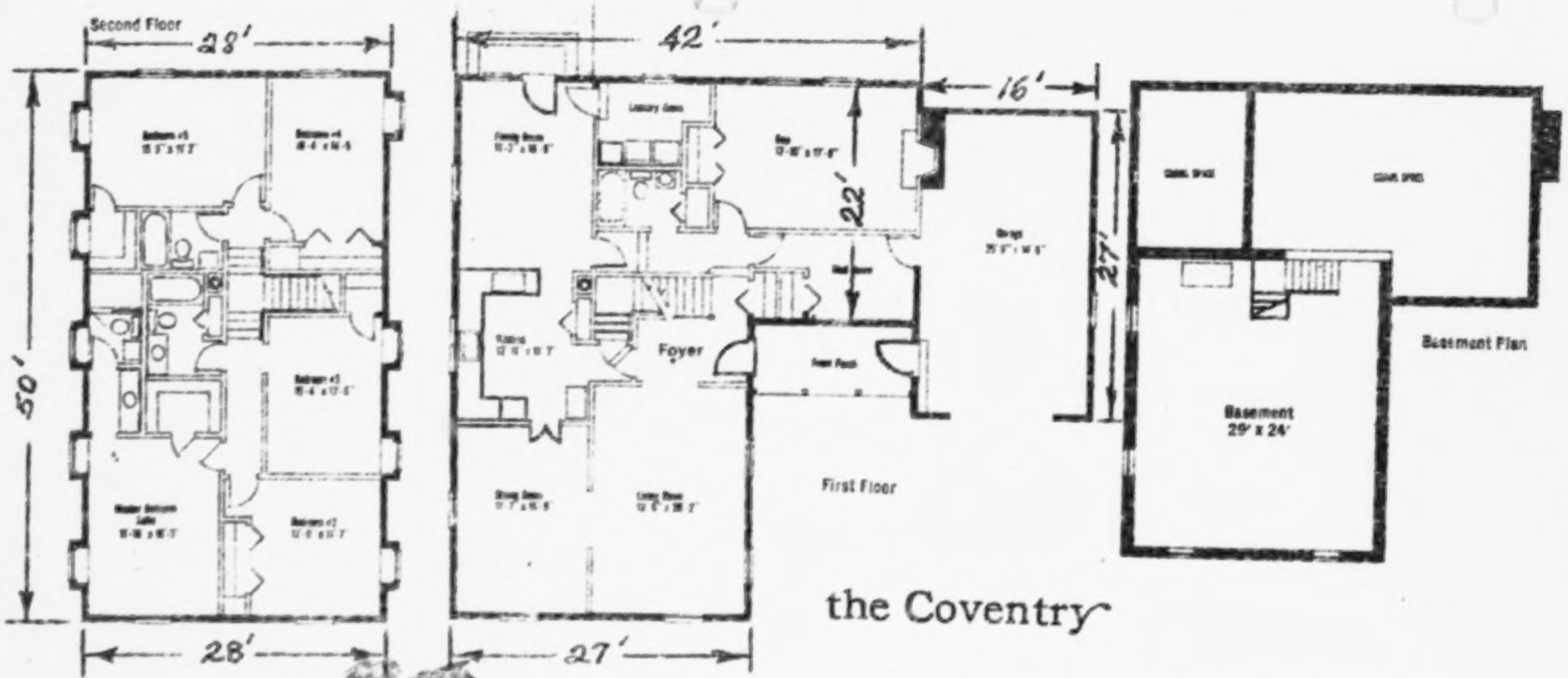
Second Floor

First Floor

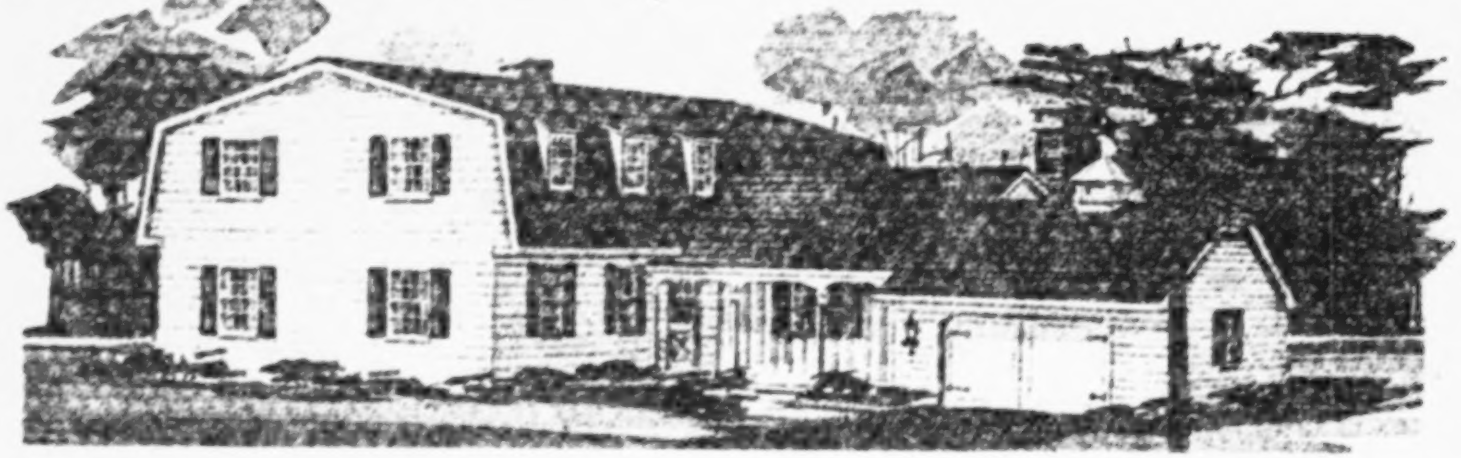
TWO-STORY

Cost--$12.00/sq. ft.

Estimated cost of construction: ______________________


Second Floor
28'
50'
28'
42'
16'
22'
27'
Foyer
27'
First Floor
Basement
29' x 24'
Basement Plan

the Coventry



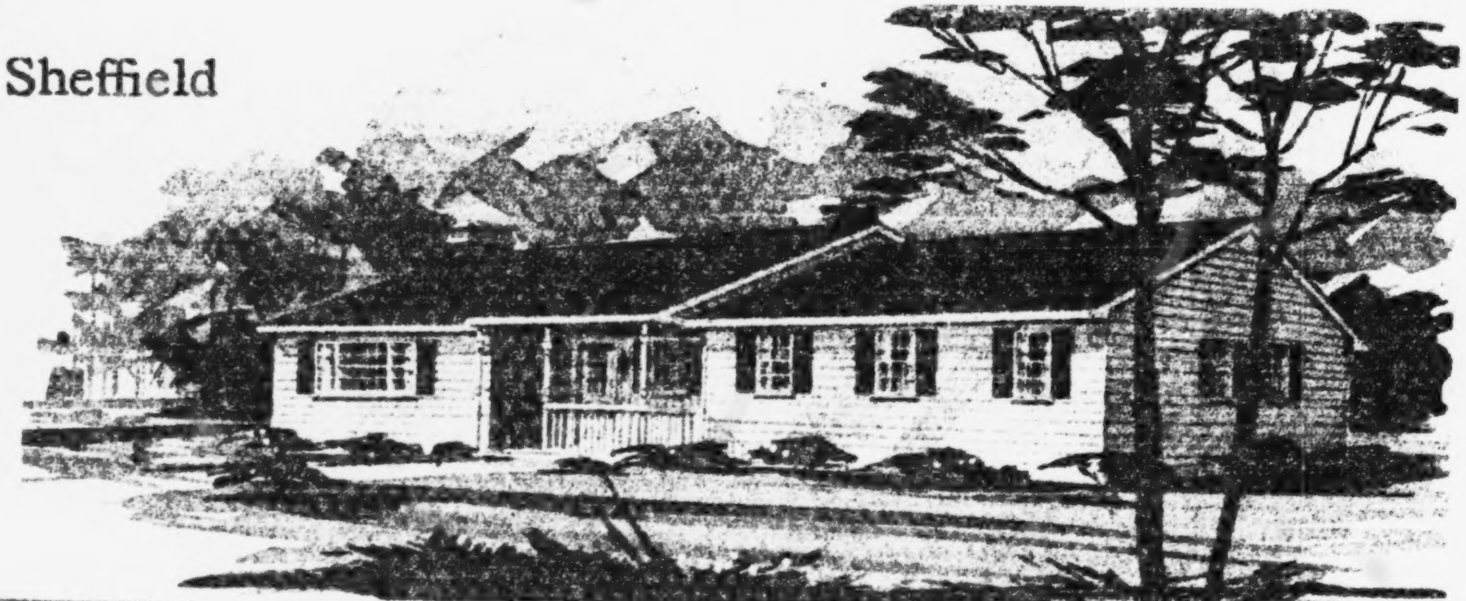
LARGE TWO-STORY

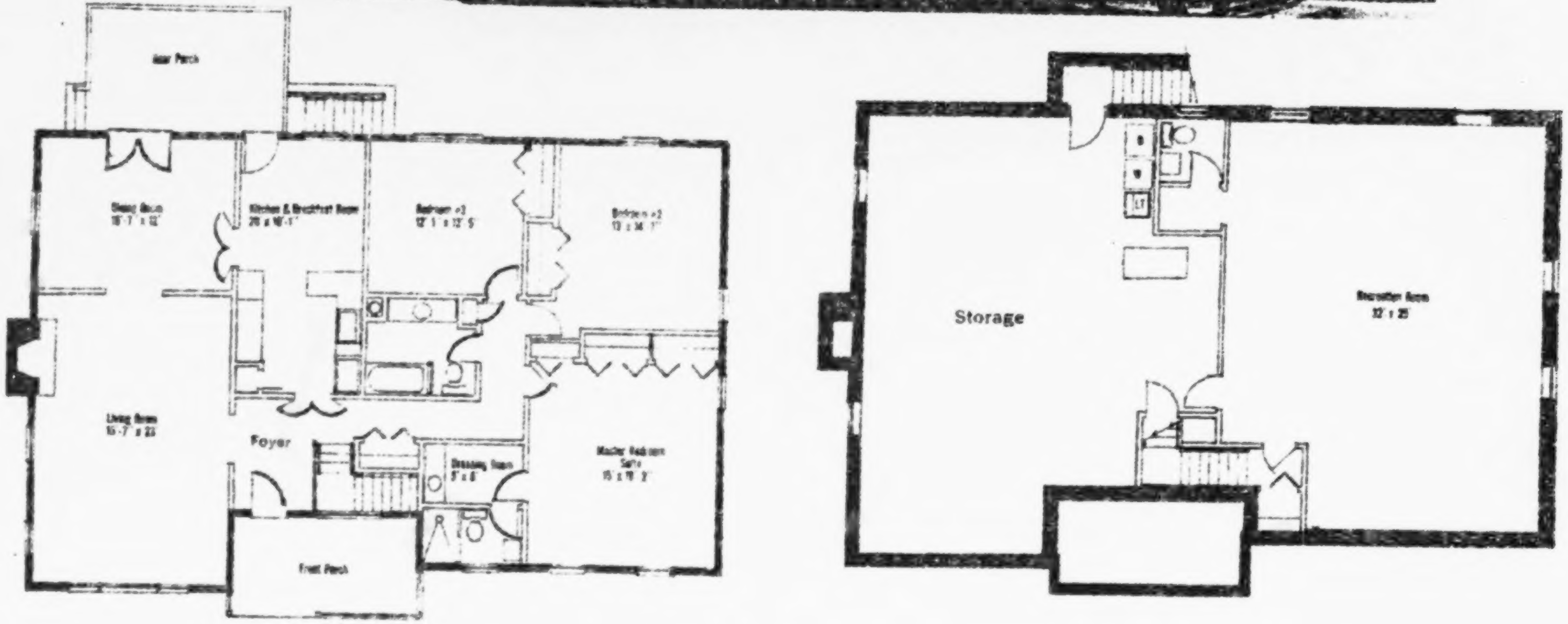
Cost--$13.00/sq. ft.
$ 5.00/sq. ft. for garage

(Cost of basement included in estimate for living space)

Estimated cost of construction: ______________________

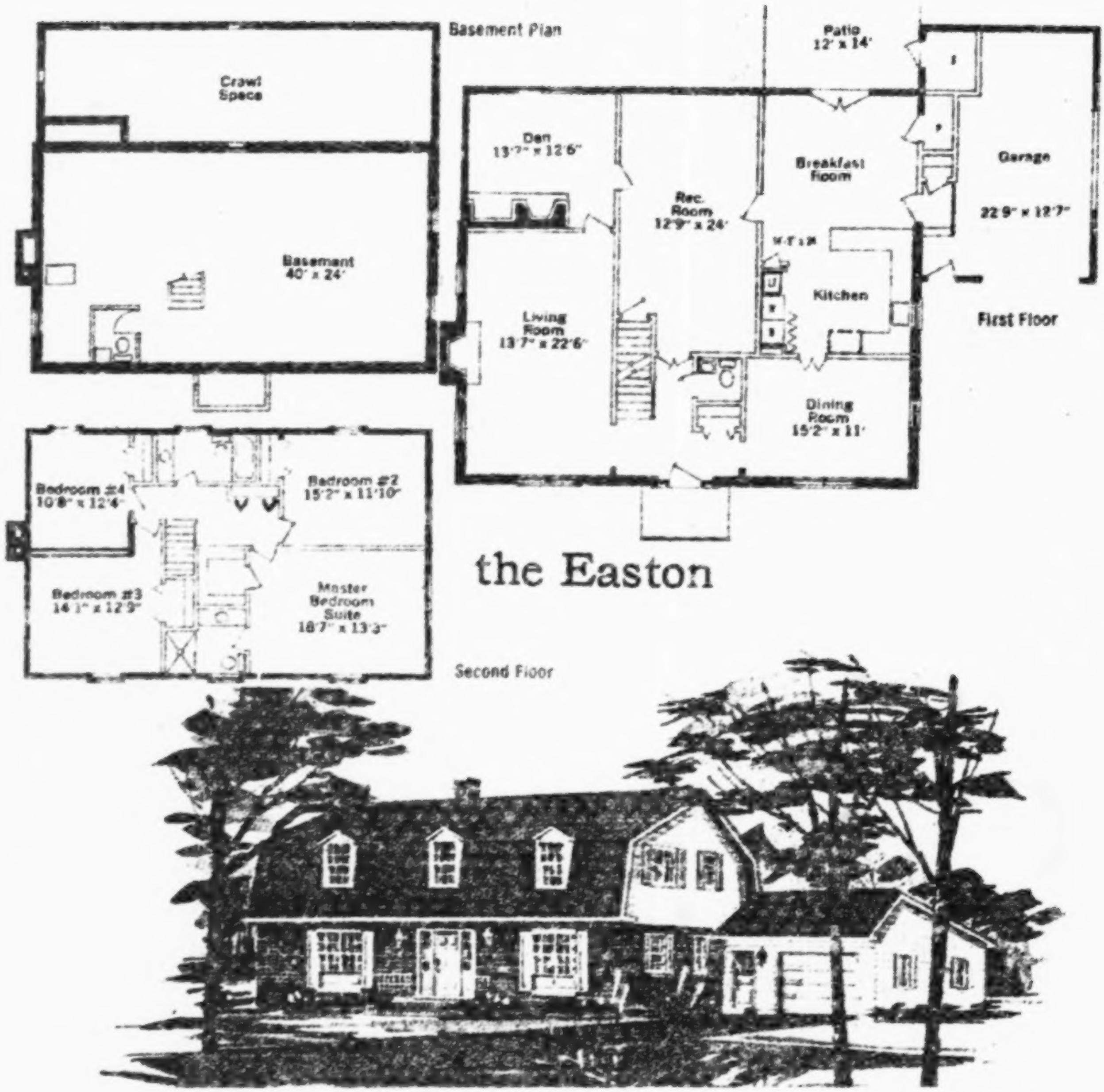
the Sheffield




Rear Porch
Dining Room
Kitchen & Breakfast Room
Bedroom #3
Bedroom #2
Living Room
Foyer
Dressing Room
Master Bedroom Suite
Front Porch
Storage
Recreation Room

RANCHER

Use a scale of $\frac{1}{16}$ inch represents 1 foot and determine the outside dimensions of the first floor only. Find the cost of the construction of this rancher at the rate of $14.00 per square foot.


Basement Plan
Crawl Space
Basement 40' x 24'
Den 13'7" x 12'6"
Rec. Room 12'9" x 24'
Breakfast Room
Patio 12' x 14'
Garage 22'9" x 12'7"
Kitchen
Living Room 13'7" x 22'6"
Dining Room 15'2" x 11'
First Floor
Bedroom #4 10'8" x 12'4"
Bedroom #2 15'2" x 11'10"
Bedroom #3 14'1" x 12'9"
Master Bedroom Suite 18'7" x 13'3"
Second Floor
the Easton

TWO-STORY

Use a scale of $\frac{1}{16}$ inch represents one foot and find the outside dimensions of the first and second floor and the garage. Estimate the construction cost of this home at a rate of \$13.00 per square foot for the first and second floors and \$5.00 per square foot for the garage.

I. Activity: Can I Afford It?

II. Objectives: The student should be able to:

A. State a basic rule determining income necessary to be able to consider a home loan of any size

B. Change hourly wages and weekly salary to an equivalent annual salary

C. Determine whether various rates of income are sufficient to consider a certain mortgage loan

III. Background Information:

Once the student has gained an understanding of the prices of homes, it is fitting to have him consider how he could borrow the money and whether or not he can afford it. The basic rules that most bankers use to advise applicants for loans are on the student work sheet. Some additional factors are:

A. Salary of wife is not usually included to determine the basic income figure of the applicant.

B. Part time or overtime income is not usually included to determine the basic income figure.

Many students have not viewed a typical income figure that they may receive in the light of an annual rate or in comparison to present day costs of living. This activity may help motivate their thinking as to the need for considering a possible vocation and the income they will need.

IV. Materials: Student work sheets entitled, "Can I Afford It?"

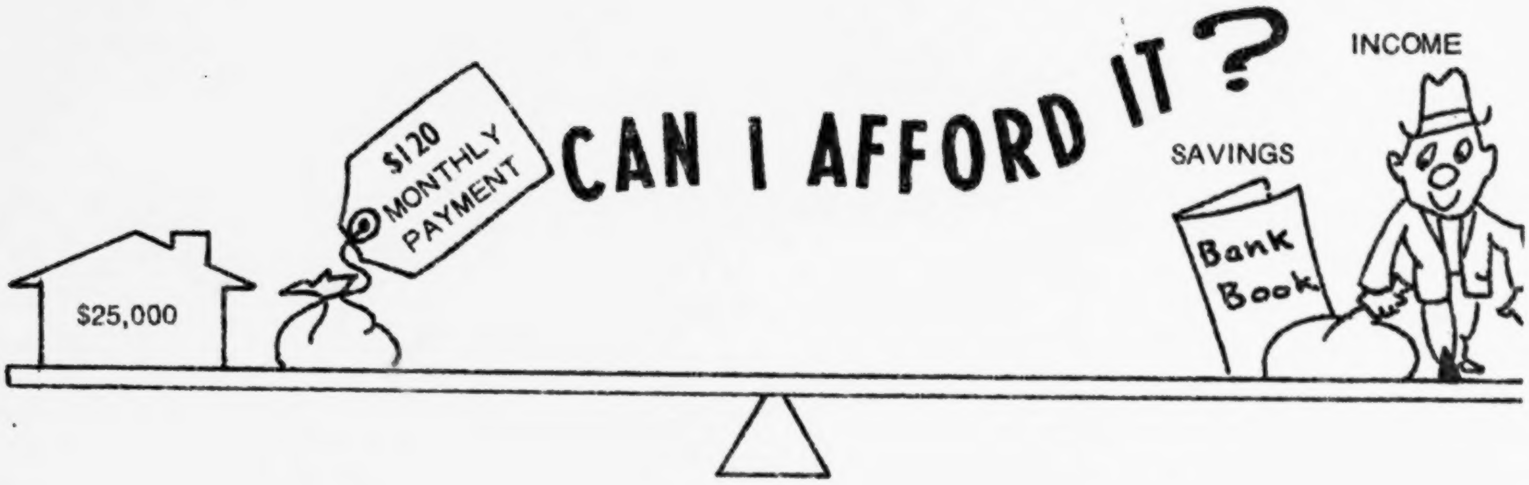
V. Suggested Procedure:

A. Conduct a brief discussion reviewing basic costs of homes.

B. Ask students how they think loans are obtained. Discuss their responses.

C. Distribute student work sheet, "Can I Afford It?"

D. Proceed through the comments on the sheet with the students. Be flexible. Allow students to respond to comments and questions. Allow time for the student to complete the chart. Solicit reactions to the solutions of the problems.



Suppose you are considering a $22,000 home. Can you afford it? Suppose also that you have $3,500 in your savings account. Most banks or savings and loan associations require a certain down payment. Suppose you go to the Plunketville Savings and Loan Association which requires 10% of the purchase price as a down payment.

How much will the Plunketville Savings and Loan Require?

____

Can you afford it - - so far? ____________________

Even if you have the required down payment the lender may be very concerned as to your ability to pay the balance. Why?

____

He would first examine your income using a basic "rule of thumb." Most banks state that the amount of the loan should not exceed 2 1/2 times your annual income. Suppose you earn $3.50 an hour. Can you still consider this $22,000 home?

Amount of loan = $22,000 - $2,200 down payment = $__________

My annual income based on $3.50 an hour, 40 hour week and 52 week year is:

The bank will loan about $2\frac{1}{2}$ times this, which is ____________________?

Therefore, I (will/will not) be able to borrow.

Calculate the annual income for each of the following rates, and complete the chart.

RATE	ANNUAL INCOME	POSSIBLE TO BORROW $19,800? (Yes or No)
$2.75 per hour		
$120.00 per week		
$1.65 per hour		
$5.25 per hour		
$240.00 per week		

I. Activity: The Monthly Payment

II. Objectives: The student should be able to:

A. State a basic rule that bankers use in suggesting the size of your monthly payment in relation to your income. (This rule appears on the student work sheet.)

B. Calculate the total amount repaid on a given loan at a certain rate for a given number of years.

C. Determine amounts of interest over the period of the loan by finding the difference between the total repaid and the amount borrowed.

D. Determine the amount saved when borrowing at a lower rate of interest.

E. Determine the amount saved when borrowing over a shorter period of time.

III. Background Information:

Most students will eventually come in contact with "the monthly payment." Their first contact, especially for the boys, will probably be the monthly payment for an auto loan. This lesson deals solely with the monthly payment for a home loan. This is not to suggest that a lesson or discussion could not evolve concerning auto loans. In fact, some of the principles covered in this lesson could be applied to an auto loan, such as the computation of the actual interest paid when repaying the car loan. A point that would be of importance to the student concerning the auto loan is that most dealers finance a loan themselves. However, the interest may be higher and it may be wise to investigate a bank loan or a credit union loan. Your own SEBCO Credit Union representative could supply information on this.

IV. Materials: Student work sheets entitled,

"Now, How About Monthly Payments?"

"You Be The Banker!"

Monthly payment chart. (This should be saved by the student for future use.)

V. Suggested Procedure:

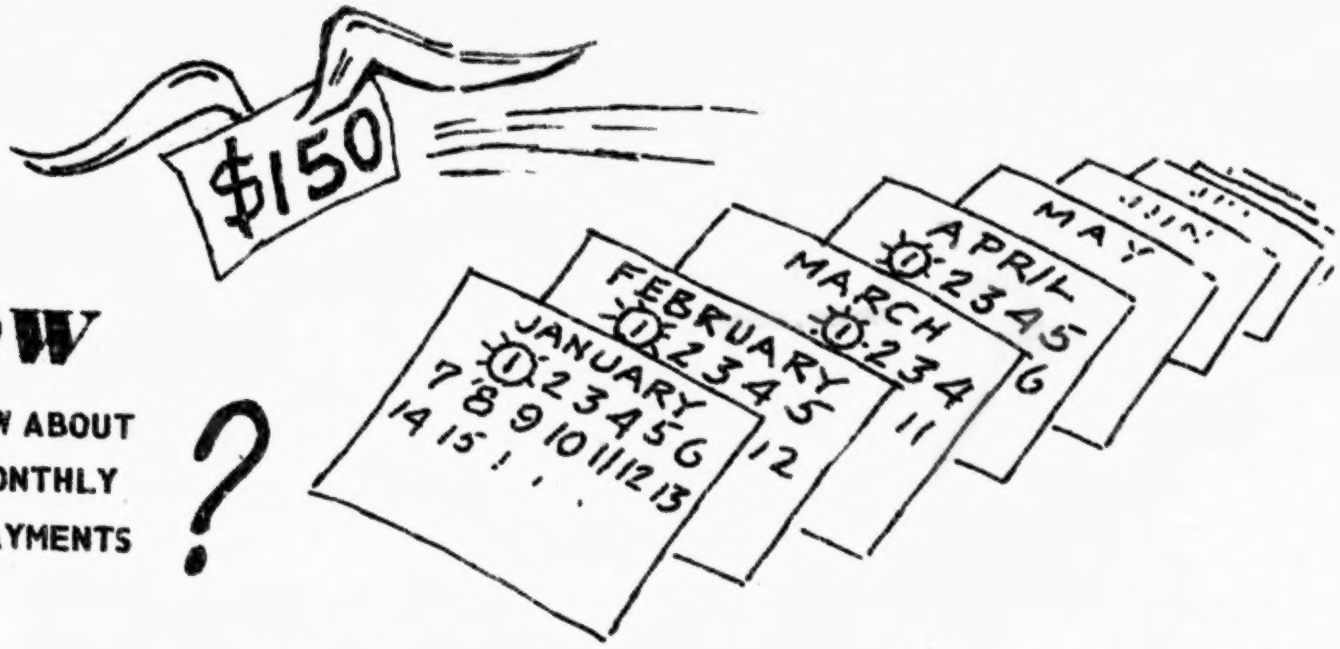
A. Most students will probably have some knowledge of installment buying and monthly payments. A brief discussion based on student experience with payments and then leading to the topic of borrowing large sums of money would be appropriate. There should have already been groundwork laid for this in previous lessons concerning the costs of homes and the income necessary to afford these costs.

B. Distribute the work sheet entitled, "Now How About Monthly Payments ?"

C. Read through and discuss the material up to Problem 1. Allow time for the students to calculate the problem stated in this section.

D. Distribute the monthly payment chart. Do problems 1 and 2 with the students. Allow class time for them to complete up to problem 8. It will be wise to introduce the remaining problems, possibly during the next day. Emphasize the large difference in amount when comparing two interest rates that vary only by $\frac{1}{2}$%.

E. In order to provide more experience in using the monthly payment chart, follow up this activity with the work sheet entitled, "You Be The Banker."



NOW

HOW ABOUT MONTHLY PAYMENTS ?

Once the bank tentatively O.K.'s your loan, you will need to decide over what period of time you need to repay the money. This will be determined somewhat by your choice and your ability to repay. Large loans are usually repaid in 15, 20, 25, or 30 years. Would you expect the monthly payment for a 25 year loan to be more or less than the payment for a 10 year loan? ____________________. Many bankers suggest that your monthly payment should not be larger than your salary or income for one week. If you are earning $3.50 an hour, could you consider a monthly payment of $150.00 per month? ____________________ If you earn $10,400 a year, what is the highest monthly payment you should consider using this rule of thumb? (Remember, 52 weeks per year.) ____________________
If you were 40 years old, the lender may hesitate giving you a 30 year loan. Why? ____________________

Now that you have examined some of the factors affecting the possible range of your monthly payment, consider this question. If you could borrow $14,000 on a plan that was about $3,000 cheaper than another, would you settle for the first plan? Let's investigate this further. You will need the chart of monthly payments to answer the following questions:

Problem 1: You earn $3.50 an hour. The greatest amount you should consider as a monthly payment is ________________. (Use the "one week income" rule.)

2. You need to borrow \$16,000. A bank will lend you the money at $6\frac{1}{2}$% interest. You must decide how long you want to take to repay. You can see from the chart that your budget will allow any of the given repayment periods. Suppose you select the lowest payment possible, \$101.13 per month for 30 years. Determine the amount you would repay during the 30 years.
30 (years) x 12 (months per year) x 101.13 = \$______________.
3. The difference between this amount and the \$16,000 you borrowed is the actual interest you pay. What is the amount of interest? ________
4. Follow this same procedure, but use a 25 year repayment period. What is the total repaid? ______________________________.
5. What is the amount of interest? ________________________.
6. What would you save by repaying in 25 years? ______________.
7. What is the difference in the monthly payment for a 25 year loan and a 30 year loan?
8. Find the amount you would save if you could repay the same loan in 15 years rather than 30 ______________________________.

Suppose a bank will lend you the \$16,000 at $6\frac{1}{2}$%. Another bank lends at 6%. Let's see what this little $\frac{1}{2}$% difference will mean to you in 25 years. Suppose you are borrowing \$18,000. Determine the amount of interest you will pay during 25 years at $6\frac{1}{2}$%.

Monthly payment at $6\frac{1}{2}$% (from chart) = ____________
Total repaid = ______________________________
Amount of interest = ________________________

Now find the amount of interest paid over 25 years at 6%.

Monthly payment at 6% = ______________________
Total repaid = ______________________________
Amount of interest = ________________________

The difference between the interest paid at the two rates is __________.
(Would you get the same result by finding the difference between the two monthly payments and multiplying this by 25? Try it.)
Do you see any reason for shopping around before borrowing money?

MONTHLY PAYMENT AT 6% INTEREST

Amount of loan	15 Years	20 Years	25 Years	30 Years
$10,000	84.39	71.64	64.43	59.96
$12,000	101.27	85.97	77.32	71.95
$14,000	118.14	100.30	90.21	83.94
$16,000	135.02	114.63	103.09	95.93
$18,000	151.90	128.95	115.98	107.92
$20,000	168.77	143.29	128.86	119.91

MONTHLY PAYMENT AT 6 1/2% INTEREST

Amount of loan	15 Years	20 Years	25 Years	30 Years
$10,000	87.11	74.56	67.52	63.21
$12,000	104.54	89.47	81.03	75.85
$14,000	121.96	104.38	94.53	88.49
$16,000	139.38	119.30	108.03	101.13
$18,000	156.80	134.21	121.54	113.78
$20,000	174.22	149.11	135.04	126.41

MONTHLY PAYMENT AT 7% INTEREST

Amount of loan	15 Years	20 Years	25 Years	30 Years
$10,000	89.88	77.53	70.68	66.53
$12,000	107.86	93.03	84.82	79.84
$14,000	125.84	108.55	98.96	93.15
$16,000	143.82	124.05	113.09	106.45
$18,000	161.80	139.56	127.22	119.76
$20,000	179.77	155.06	141.36	133.06

YOU BE THE BANKER!

1. Denny Deepindet applies for a loan at your bank. He wants to borrow $10,000 for a home. He earns $1.75 an hour. Would you consider making a loan? (Use the 2 1/2 times the yearly income rule.) Show your reason for this decision.
2. Your bank lends money at 7% interest on home loans. Mr. and Mrs. Fullabuck have the necessary income to borrow their requested $20,000. They can't understand why it would pay them to select the 25 year period over the 30 year period. They are hard to convince, so show them plainly on paper the advantage of a 25 year period.
3. Mr. Knott D. Cide has many friends at a nearby bank. Because of this, he would like to deal with that bank. He plans to borrow $18,000 to be repaid in 30 years at 7% interest. Your bank is lending at 6 1/2%. You tell him that you can save him enough to help put one of his children through college! Show him what you mean.

I. Activity: Have I Overlooked Anything?

II. Objectives: The student should be able to:

A. Define closing costs

B. Name at least three typical costs encountered when settling for a loan

C. Calculate the monthly tax payment and insurance premium when a yearly amount is given

III. Background Information:

Many have plunged into serious thinking about mortgages without considering additional expenses such as those listed above. This is the reason for the starry eyed characterization on the student work sheet.

IV. Materials:

A. Student work sheet entitled, "Have I Overlooked Anything?"

B. A monthly payment chart. (Students should already have one from a previous exercise.)

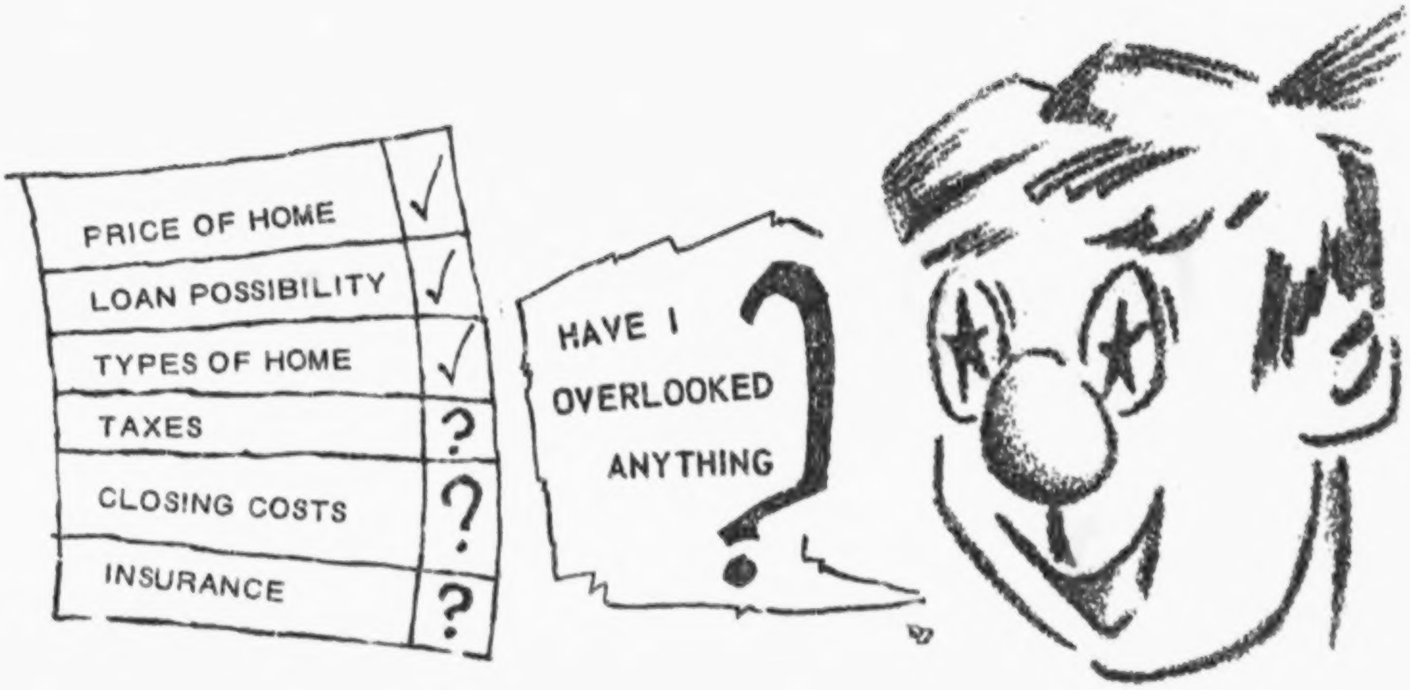
V. Suggested Procedure:

A. Distribute the work sheet entitled, "Have I Overlooked Anything?" Use the heading of the sheet to stimulate a discussion of its meaning as outlined in Background Information above.

B. Explain the specific closing costs. Allow sufficient time for students to calculate the total.

C. Proceed through the rest of the text of the work sheet. A brief discussion of fire insurance may be necessary.

D. Have students complete the monthly payment problems at the end of the sheet.


PRICE OF HOME ✓
LOAN POSSIBILITY ✓
TYPES OF HOME ✓
TAXES ?
CLOSING COSTS ?
INSURANCE ?
HAVE I OVERLOOKED ANYTHING ?

Two things that are often overlooked when obtaining a home are closing costs and taxes. Closing costs are amounts that have to be paid the day you receive your money from the bank. This is called "settlement." Some of these costs are:

Title fee	$250.00
Title insurance	$116.00
Notary fees	$ 1.50
State stamps	$107.80
Survey of location	$ 40.00
First year insurance premium	$ 75.00
Property tax for remaining portion of year	$150.00
Total:	$

Find the total of these charges.

When you solve problems concerning monthly payments, the amount of the payment just included a portion to reduce the loan (principal) The remainder was for interest. There are often additional amounts included. The bank may require you to have your property tax and your fire insurance included in your monthly payment.

Suppose the taxes for your property were $374.76 for a year. Your insurance is $69.60 a year. You are borrowing $14,000 at $6\frac{1}{2}$% interest for 25 years. What will the monthly payment be?

Taxes per month = $__________

Insurance per month = $__________

Monthly payment on
$14,000 (from chart) = $__________

Total monthly payment = $__________

1. Find the total monthly payment for a loan of $16,000 at 7% interest for 25 years including payment for a $342.00 tax bill and a $66.00 insurance premium.
2. Find the total monthly payment for a loan of $10,000 at 6% interest for 15 years. Include the payment for a $261.00 tax bill and a $57.60 annual insurance premium.

I. Activity: A Taxing Problem

II. Objectives: The student should be able to:

A. Calculate the assessed value of a home when the assessment rate and fair market value are given

B. Calculate yearly taxes when the assessed value and tax rate are known

C. State at least one reason for the assessed value to increase and at least one reason for the assessed value to decrease

III. Background Information:

This is not just a set of problems pertaining to the computation of taxes when given the rate. An attempt has been made to create an understanding of:

A. the reason for property taxation

B. the duty of a tax appraiser

C. assessed value

D. the manner by which a property tax rate is expressed.

The work sheet provides most background information needed but any additional personal experiences of the teacher would do much to enhance the lesson. An excellent article on this subject may be found in the June, 1968 issue of Reader's Digest entitled, "The Tax That Cheats Almost Everyone" by James N. Miller. Students could be assigned to read this or it could be discussed with the class.

IV. Materials: Work sheet entitled, "Home Ownership, A Taxing Problem

V. Suggested Procedure:

A. Distribute student work sheet entitled, "Home Ownership, A Taxing Problem."

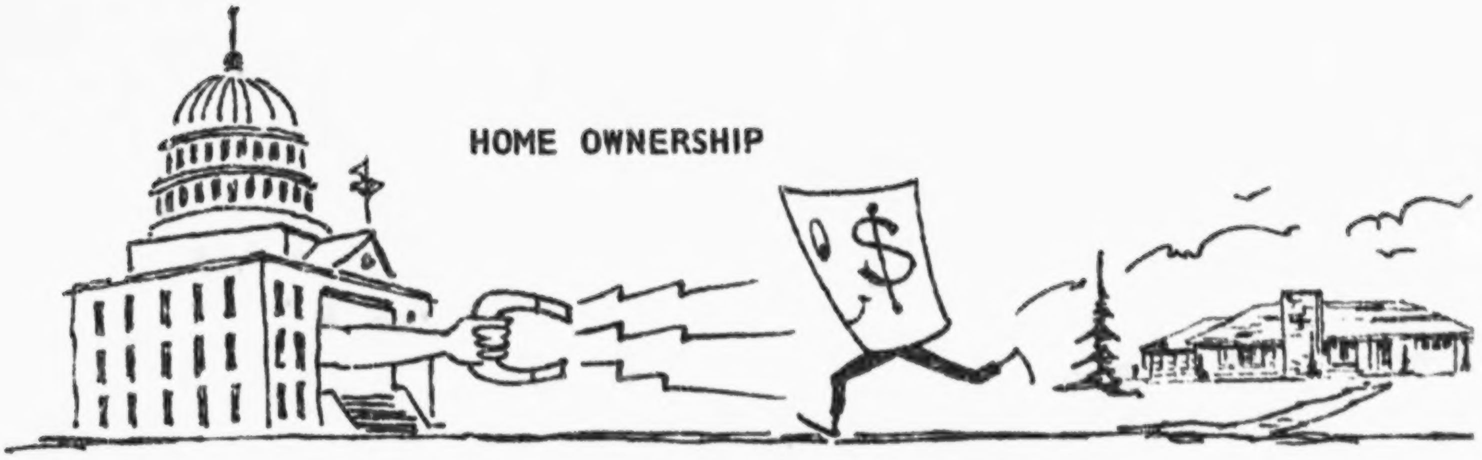
B. Have students respond to the significance of the cartoon at the top of the work sheet.

C. Read through the first part of the work sheet up to the description of assessed value.

D. Orient students to their assignment of completing the chart.

E. Use the result in the chart to help answer the thought questions at the end of the sheet.

HOME OWNERSHIP



A TAXING PROBLEM!

Your county must have funds for many services. One of the major services is public education. Schools, salaries and equipment must be paid for. One of the major sources for the money needed for these services is the local real estate or property tax. Every person who owns land and a home must pay a tax on this property. The manner in which your tax is determined is something you should know about. An appraiser from the county will inspect your home to establish a fair value for it, judged on prices of similar homes in that area. Your tax is not usually based solely on this value, but on an assessment value. The county government will have established assessment rates. For example, suppose an assessment rate is 60%. Then if your home is appraised at $20,000, your tax would be based on 60% of $20,000 or $12,000. This $12,000 is the assessed value.

A sample property tax rate is $3.25 per $100. This means that for every $100 of assessed value you must pay $3.25 each year. How many $100 are in an assessed value of $12,000? ____________________

What is the amount of the tax on $12,000? ____________________

Is this tax rate the same as a rate expressed as 3.25% of the assessed value? ______________________________

Now, complete columns C and E of the chart.

FAIR MARKET VALUE	ASSESSMENT RATE	ASSESSED VALUE	TAX RATE	TAX
$20,000	60%		$3.25 per 100	
$20,000	52%		$3.25 per 100	
$30,000	64%		$2.25 per 100	
$30,000	64%		$3.55 per 100	
$28,000	60%		$2.80 per 100	
$26,000	60%		$2.80 per 100	
$29,500	62%		$3.15 per 100	

THOUGHTS TO TAX YOUR MIND

1. If the county government decided to raise the rate of assessment, would this raise the amount of taxes collected?
2. What is another way in which the government can increase the amount of taxes collected?
3. Did your county raise its tax rate this year?
4. If you feel your assessed value is too high, you have the right to appeal or present your reasons to the assessment office. What are some causes for this fair value of your home to become lower?

Manufacturing Activities

MANUFACTURING ACTIVITIES

I. Activity: Graduations on the Steel Scale

II. Objectives: The student should be able to:

   A. Apply the rules for simplifying fractions

   B. Identify various readings on a scale (ruler)

III. Materials:

   A. One 6" metal scale for each student

   B. One set of transparencies and overlay entitled:

      1. Quarter inch scale

      2. Eighth inch scale

      3. Sixteenth inch scale

      4. Thirty-second inch scale

      5. Sixty-fourth inch scale

   C. One work sheet for each student entitled, "A Six-Inch Scale"

IV. Suggested Procedure:

   A. Use the transparency with only quarter inch scale

      1. Show the students there are "4" divisions per inch

      2. Therefore, each division is $\frac{1}{4}$ inch.

   B. Then point to various divisions and have the students identify them.

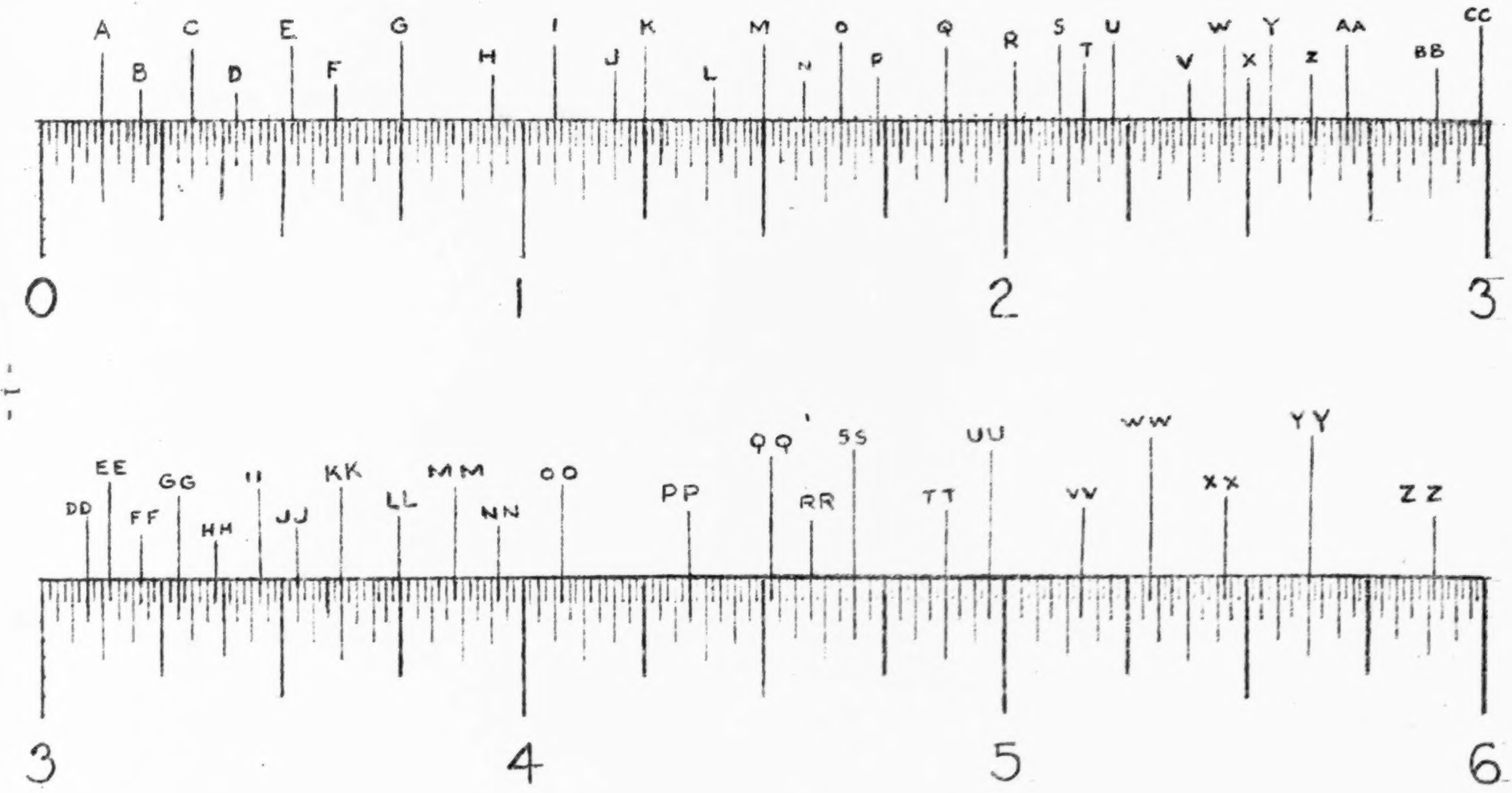
   C. Continue the same procedure using transparencies for 8ths, 16ths, 32nds, and 64ths.

   D. After discussing each scale, show them how the scales overlap. Review simplifying fractions here.

   E. Hand out work sheet entitled, "A Six-Inch Scale." Have student identify each letter on the work sheet.

   F. List on board various fractions to be simplified, using only denominators of 4ths, 8ths, 16ths, 32nds and 64ths. Have the students work these problems on the back of the work sheet.

A SIX INCH SCALE


A B C D E F G H I J K L M N O P Q R S T U V W X Y Z AA BB CC
0
1
2
3
DD EE FF GG HH II JJ KK LL MM NN OO PP QQ RR SS TT UU VV WW XX YY ZZ
3
4
5
6

I. Activity: Reading a Decimal Equivalents Chart

II. Objectives: The student should be able to:

   A. Change a given fraction to a decimal using chart and using division

   B. Change a given decimal to the closest fraction using chart

III. Materials:

   A. One "Brown and Sharpe Chart" on decimal equivalents

   B. Textbook, page 481

   C. Work sheet entitled, "Fractions and Decimals"

IV. Suggested Procedure:

   A. Show how to read the chart on decimal equivalents.

   B. Review how to change a fraction to decimal by division.

      1. If a chart is not available, or if a fraction is not on the chart, it will be necessary to divide.

      2. Explain the difference between terminating and repeating decimals.

      3. Use symbols for repeating decimals

         a. .232323...

         b. $.\overline{23}$

         c. $.\dot{2}\dot{3}$

   C. Show how to round off decimals.

   D. Show how to locate the closest possible fraction for a given decimal.

      Example: Change .7395 to the closest possible fraction

      1. The decimal .7395 is between .734375 and .75 on the chart.

      2. .7395 is closer to which decimal?

         a. $$\begin{array}{r} .739500 \\ \underline{.734375} \\ .005125 \end{array}$$

b. $$\begin{array}{r} .7500 \\ \underline{.7395} \\ .0105 \end{array}$$

c. Since .005125 is smaller than .0105, then .7395 is closer to .734375 or $\frac{49}{64}$.

Example: Change .54395 to the closest possible fraction

1. The decimal .54395 is between .53125 and .546875.
2. .54395 is closer to which of these decimals?

a. $$\begin{array}{r} .54395 \\ -\underline{.53125} \\ .01270 \end{array}$$

b. $$\begin{array}{r} .546875 \\ -\underline{.543950} \\ .002925 \end{array}$$

c. Since .002925 is smaller than .01270, then .54395 is closest to .546875 or $\frac{35}{64}$.

FRACTIONS AND DECIMALS

I. Change each of the following fractions to a decimal using table.

a. $\frac{3}{32}$

b. $\frac{5}{64}$

c. $\frac{9}{16}$

d. $\frac{7}{32}$

e. $\frac{1}{8}$

f. $\frac{11}{32}$

g. $\frac{11}{16}$

h. $\frac{5}{8}$

i. $\frac{7}{16}$

j. $\frac{11}{64}$

II. Locate the closest fraction to nearest 64th using table.

a. .3913

b. .4675

c. .6354

d. .8913

e. .3431

f. .7212

g. .5744

h. .1896

i. .2368

j. .9250

III. Suppose a chart is not available, then it will be necessary for you to divide to change a fraction to a decimal (3 decimal places, rounded off to 2 decimal places).

a. $\frac{1}{11}$

b. $\frac{1}{6}$

c. $\frac{1}{9}$

d. $\frac{3}{7}$

e. $\frac{5}{9}$

f. $\frac{12}{13}$

g. $\frac{1}{10}$

h. $\frac{5}{14}$

i. $\frac{2}{9}$

j. $\frac{8}{21}$

I. Activity: Reading the Steel Scale

II. Objectives: The student should be able to:

Measure objects with a steel scale to the nearest $\frac{1}{4}$", $\frac{1}{8}$", $\frac{1}{16}$", $\frac{1}{32}$", $\frac{1}{64}$"

III. Materials:

A. One steel scale for each student

B. One steel scale kit

C. One work sheet for each student entitled, "Steel Scale Measurement"

IV. Suggested Procedure:

A. Use one of the following lab approaches:

1. Place bolts around room and let students measure each at random.

2. Divide students into groups and give each group a portion of the kit, then exchange portions among groups.

3. Have the students in their assigned seats and give each student a bolt to measure. When students have measured their bolts have them pass it back. Last student in a row will take his bolt up to the front of the next row. Last student in the last row will take his bolt to the first student in the first row.

4. Have students measure objects in kit when they have finished other assigned work.

B. Have each student measure the numbered bolts to the nearest $\frac{1}{4}$", $\frac{1}{8}$", $\frac{1}{16}$", $\frac{1}{32}$", $\frac{1}{64}$" and record each answer in the proper column on work sheet.

1. When measuring bolts have student measure from inside head of the bolt to end of the bolt.

2. Number the work sheet from 1-22.

STEEL SCALE MEASUREMENTS

Directions: Measure each object to the nearest $\frac{1}{4}$", $\frac{1}{8}$", $\frac{1}{16}$", $\frac{1}{32}$", and $\frac{1}{64}$" using your 6" steel scale.

Numbers	$\frac{1}{4}$"	$\frac{1}{8}$"	$\frac{1}{16}$"	$\frac{1}{32}$"	$\frac{1}{64}$"

I. Activity: Adding Fractions on the Steel Scale

II. Objectives: The student should be able to:

Add fractions on a steel scale

III. Materials:

A. One 6" steel scale for each student

B. One work sheet for each student entitled, "Adding Segments on a Steel Scale"

IV. Suggested Procedure:

A. Hand out steel scales and the work sheet.

B. Show the student how to add measurements on the scale.

C. Work the first problem on the sheet. The answer can be found by simply adding fractions or by using the scale.

V. Suggested Evaluation for Work on the Steel Scale

A. Draw a "6" scale and have students identify various readings.

B. Have students change fractions to decimals using chart in book.

C. Have students change fractions to decimals by division.

D. Have students round off decimals.

E. Have students add fractions using scales.

F. Have student measure objects during test and record answers.

ADDING SEGMENTS ON A STEEL SCALE

Directions: Add the measurement at the top of each column to the previous sum. The first one has been done for you.

Scale Reading	$\frac{1}{4}$"	$\frac{3}{8}$"	$\frac{5}{8}$"	$\frac{1}{16}$"	$\frac{3}{32}$"
1. $\frac{3}{4}$"	1"	$1\frac{3}{8}$"	2"	$2\frac{1}{16}$"	$2\frac{7}{16}$"
2. $\frac{3}{8}$"					
3. $\frac{5}{16}$					
4. $\frac{9}{32}$					
5. $\frac{1}{8}$					
6. $1\frac{1}{4}$					
7. 3"					
8. $\frac{15}{16}$					
9. $\frac{5}{64}$"					
10. $\frac{13}{64}$"					

THE MICROMETER

I. Activity: Reading a Micrometer

II. Objectives: The Student should be able to:

   A. Name the parts of a micrometer

   B. Read a micrometer given a specific setting

III. Materials:

   A. One micrometer for each student

   B. One large demonstration micrometer

   C. Chart: "How to Read Micrometers" by Brown and Sharpe

   D. One set of 3 transparencies including:

      1. Micrometer

      2. Graduated Barrel

      3. Graduated Thimble

   E. A work sheet for each student entitled, "Readings from a Micrometer"

IV. Suggested Procedure:

   A. Have several students attempt to measure thickness of a flat piece of metal with a scale. Record the various answers. Point out that we must have a more accurate measuring device than a scale.

   B. Show the large demonstration micrometer. Identify the parts using the transparency entitled, "Parts of Micrometer." Have students name the parts on demonstration micrometer.

   C. Show the one-inch micrometer that the student will be using. Ask, "Why is it called a one-inch micrometer?"

   D. Use transparency entitled, "Graduated Barrel."

      1. Emphasize that the barrel is divided into 40 parts (1" ÷ 40 = .025" for each division on the barrel).

      2. Using the transparency point to various divisions and have the students identify them.

E. Use transparency entitled, "Graduated Thimble."

   1. Emphasize that the thimble is divided into 25 parts.
   2. Ask, "How far does graduated thimble rotate in one turn?" To help answer the question use the demonstration micrometer and rotate it. Answer (.025")
   3. Since the graduated thimble moves .025" in one turn and there are 25 divisions, then $\frac{.025''}{25} = .001''$; i.e. each division equals .001.

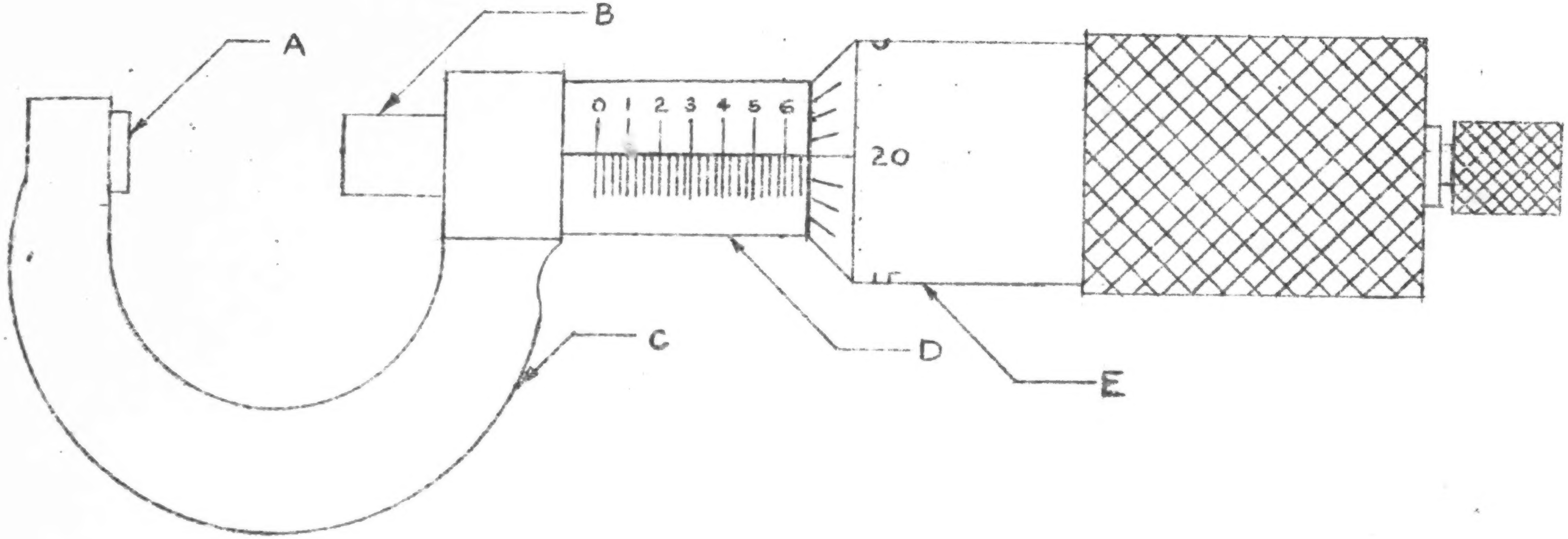
F. The reading on a micrometer is the sum of the reading on the graduate barrel and the reading on the graduate thimble.

G. Set the large demonstration micrometer on various readings and have students identify them.

H. Summary:

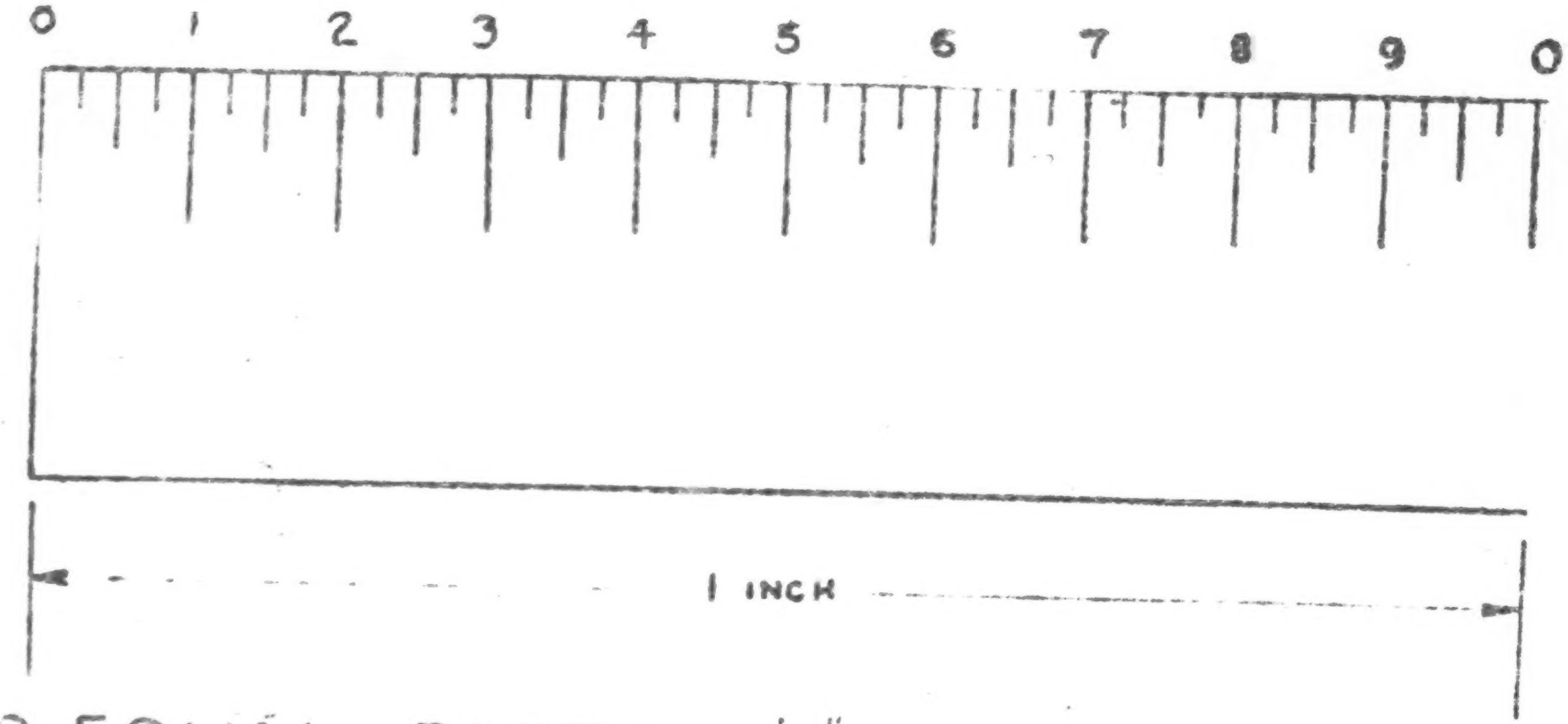
   1. Review parts.
   2. Have students complete the work sheet entitled, "Readings from a Micrometer."

MICROMETER


A
B
0 1 2 3 4 5 6
20
C
D
E

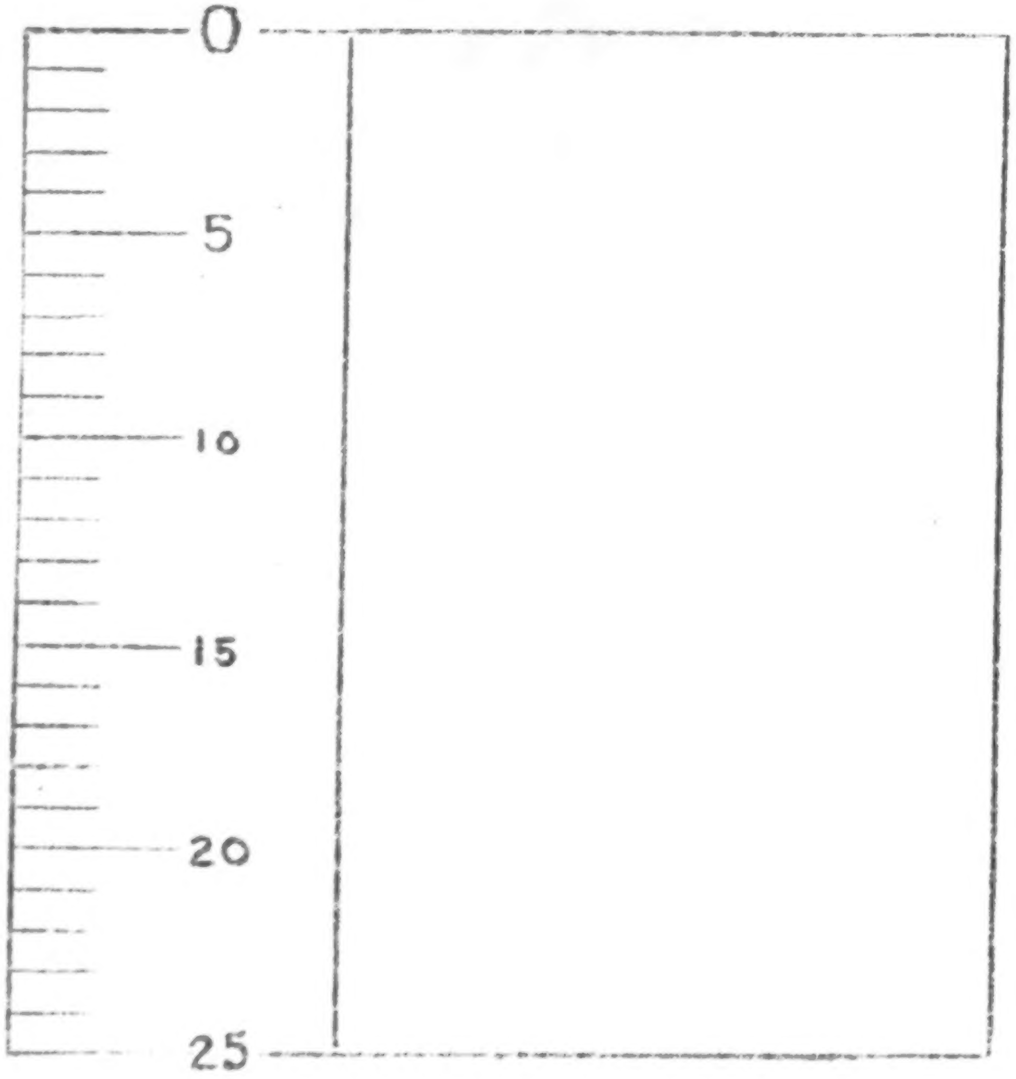
A. ANVIL
B. SPINDLE
C. FRAME
D. GRADUATED BARREL
E. GRADUATED THIMBLE

GRADUATED BARREL


0
1
2
3
4
5
6
7
8
9
0
1 INCH

40 EQUAL PARTS $\frac{1''}{40}$ .025"

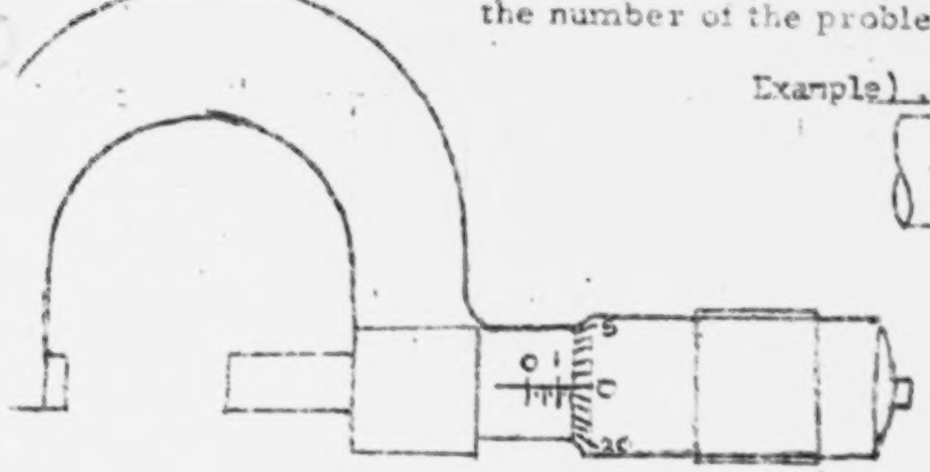
GRADUATED THIMBLE


0
5
10
15
20
25

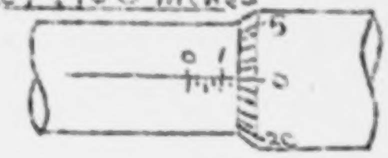
25 EQUAL PARTS $\frac{.025''}{25} = .001''$

READINGS FROM A MICROMETER

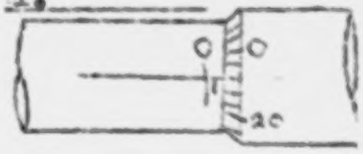
Place the reading on the micrometer to the right of the number of the problem.



Example) .150 inches



1)



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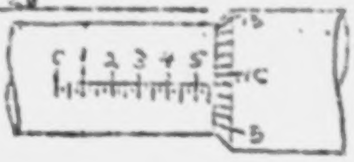
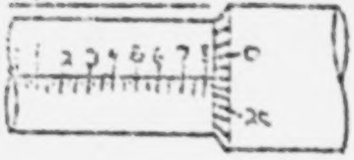
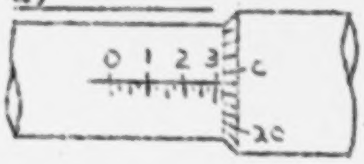

0 1 2 3 4 5
15
10
5

3)


1 2 3 4 5 6 7
0
20

4)



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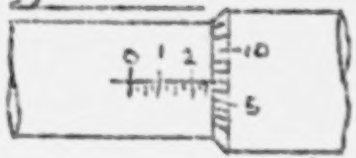

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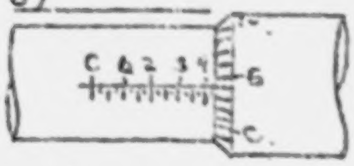

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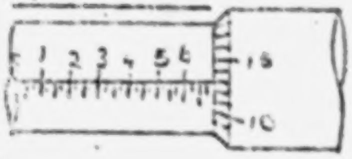
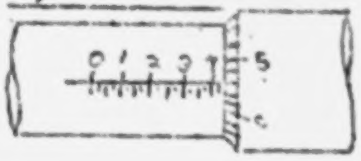

1 2 3 4 5 6
15
10

8)



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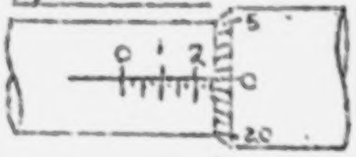

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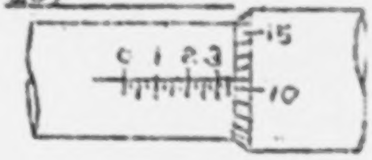

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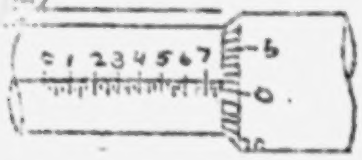
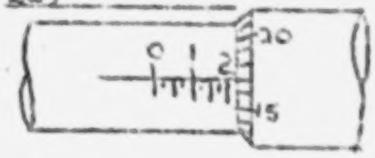

0 1 2 3 4 5 6 7
5
0
20

12)



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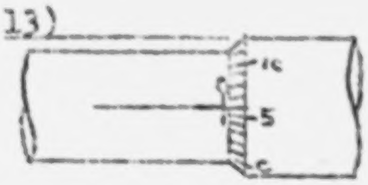

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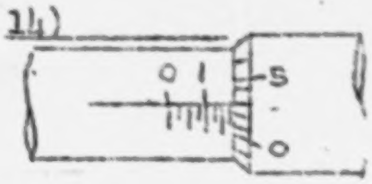

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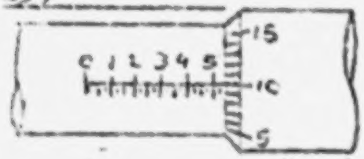
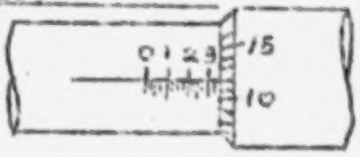

0 1 2 3 4 5
15
10
5

16)



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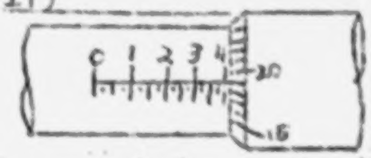

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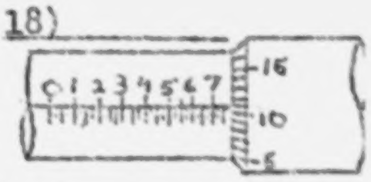
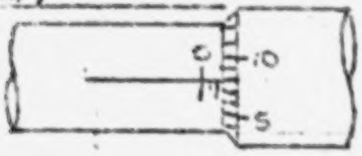

0 1 2 3 4 5 6 7
15
10
5

19)



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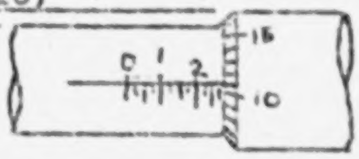

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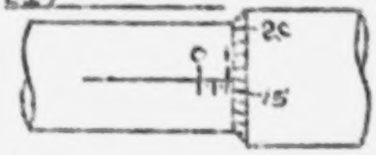

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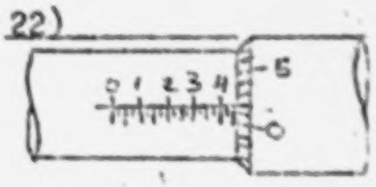

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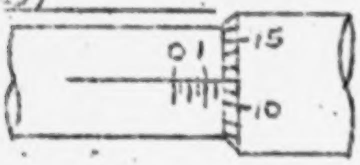

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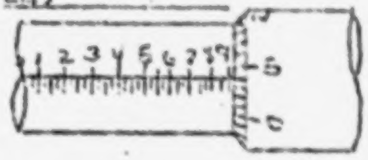
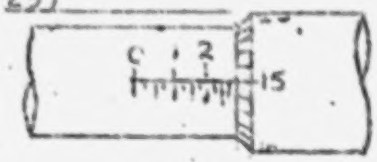

1 2 3 4 5 6 7 8 9
5
0

25)



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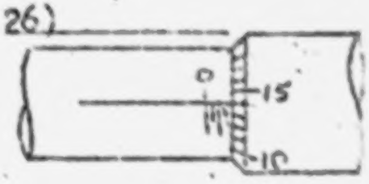

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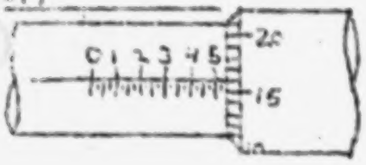
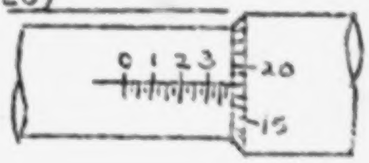

0 1 2 3 4 5
20
15

28)



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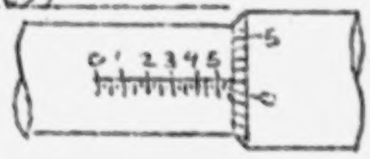

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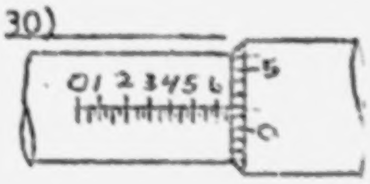


THE MICROMETER

I. Activity: Sketching Readings on a Micrometer

II. Objectives: The student should be able to sketch a micrometer given a specific reading

III. Materials:

A. One micrometer for each student

B. One large demonstration micrometer

C. A work sheet for each student entitled, "Drawing Readings on a Micrometer"

IV. Suggested Procedure:

A. Make sure students have completed the work sheet entitled, "Readings from a Micrometer" then check answers.

B. List the following 36 micrometer readings on board.

1. .131
2. .026
3. .952
4. .736
5. .780
6. .962
7. .512
8. .247
9. .654
10. .868
11. .134
12. .393
13. .103
14. .928
15. .409
16. .310
17. .538
18. .759
19. .875
20. .496
21. .084
22. .760
23. .241
24. .595
25. .476
26. .357
27. .628
28. .339
29. .325
30. .023
31. .404
32. .144
33. .663
34. .582
35. .001
36. .911

C. Hand out work sheet entitled, "Drawing Readings on a Micrometer." Hand out one-inch micormeters to help in drawing each reading.

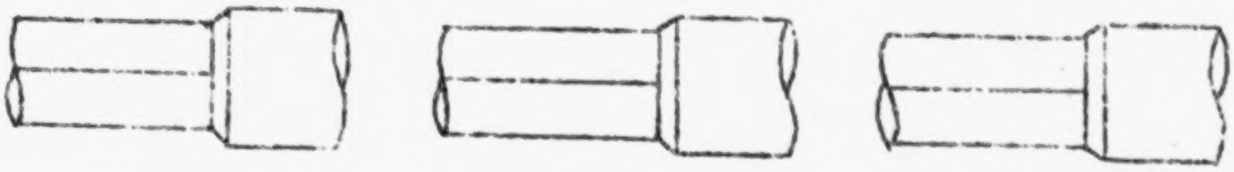
D. Let students complete the work sheet.

E. Have several students place sample sketches on the chalkboard.

DRAWING READINGS ON A MICROMETER

Directions: Show how the readings on the board look on each of the following micrometers.

1.



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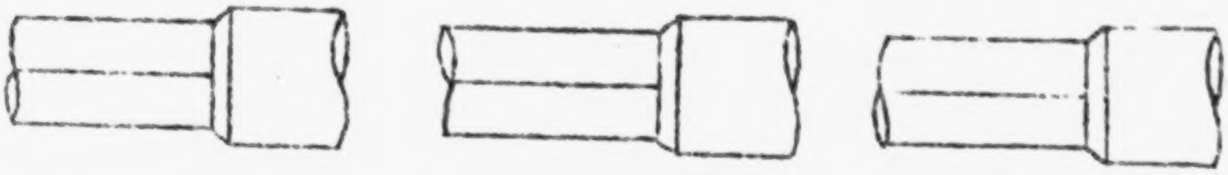
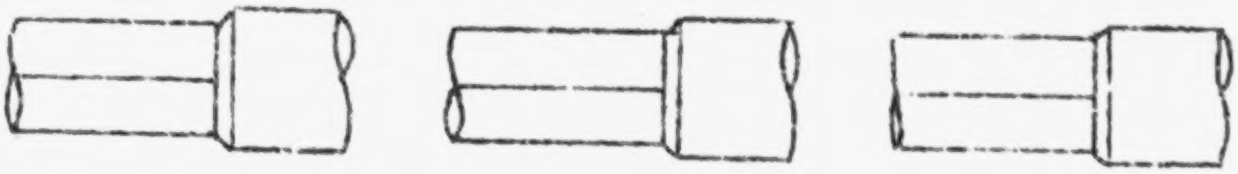
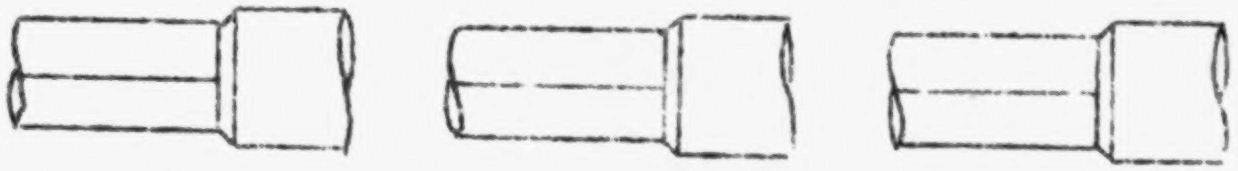


3.



4.



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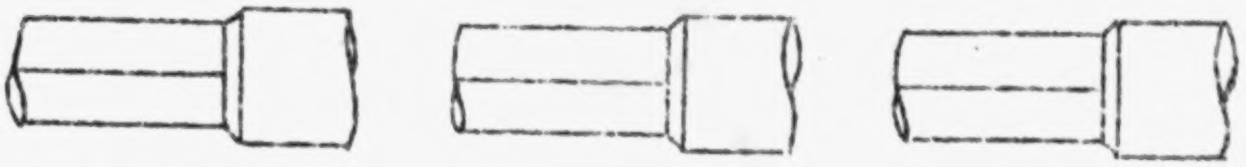

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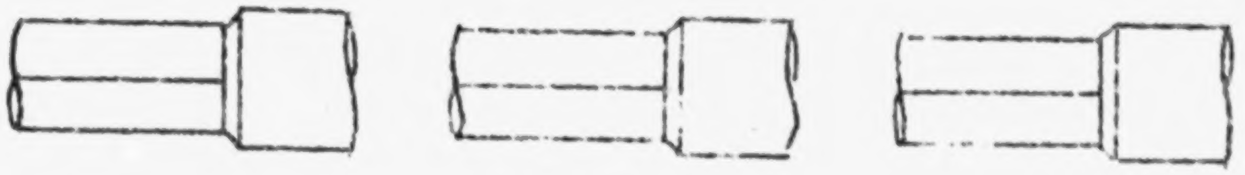

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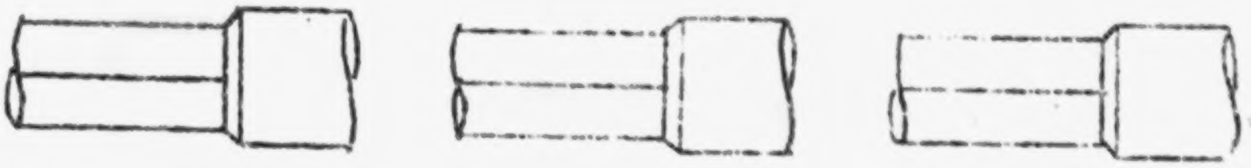

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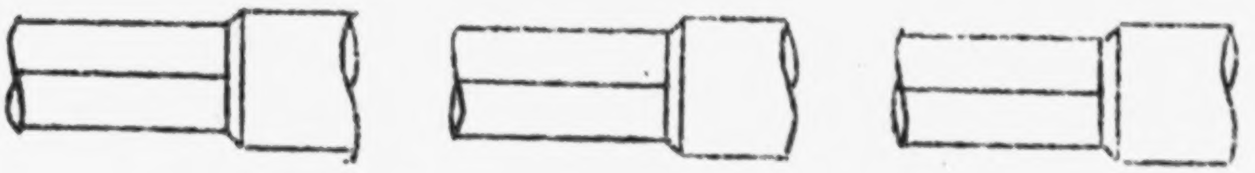

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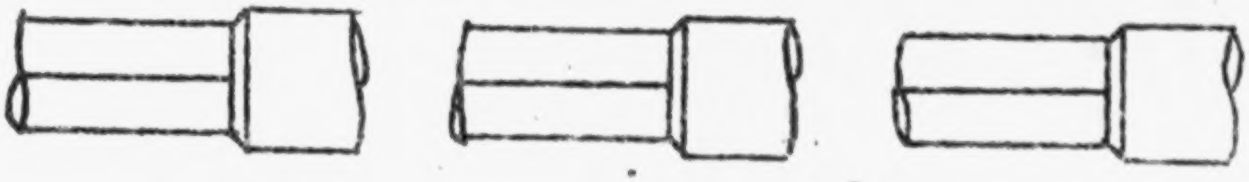


THE MICROMETER

I. Activity: Measuring with a Micrometer

II. Objectives: The student should be able to:

Measure various objects with a micrometer

III. Materials:

- A. One micrometer for each student
- B. One micrometer kit

IV. Suggested Procedure:

- A. Make sure students have completed the work sheet entitled, "Drawing Readings on a Micrometer"
- B. Hand out the micrometers
- C. Have students number from 1 to 28 on a sheet of paper
- D. Use a laboratory approach
  1. Place objects from the kit around the room
  2. Let students "mike" each object, they do not have to do them in order
  3. Remind them to record each measurement on their answer sheet
  4. Other lab approaches are given in the unit on the Steel Scale

V. Suggested Evaluation for the Micrometer Unit:

- A. Have students identify readings on a micrometer
- B. Have students draw readings on a micrometer
- C. Have students draw and label the parts of a micrometer
- D. Hand out micrometers before test. During test there will be five numbered items to be "miked" and recorded on test paper

THE VERNIER CALIPER

I. Activity: Reading a Vernier Scale

II. Objectives: The student should be able to:

A. Name the parts of a vernier caliper

B. Read a vernier caliper given a setting

III. Background Information:

A. When teaching a student to read the vernier scale it would be easier for him to start with the short cut (F-6) first, then later explain the actual development of the scale.

B. If your class has a limited number of vernier calipers use a group lesson approach.

IV. Materials:

A. Several vernier calipers for student use

B. One set of transparencies entitled:

1. "Vernier Caliper"
2. "Vernier Caliper's Beam Scale"
3. "Vernier Caliper's Vernier Scale"

C. A work sheet entitled, "Setting for Vernier Caliper"

V. Procedure:

A. Have several students attempt to measure the outside diameter of a pipe with scale and record various answers.

B. Point out that we must have a more accurate measuring device than a scale.

1. The student might suggest the micrometer if it has been studied.
2. The problem with a one-inch micrometer is that it is limited to one-inch while Vernier calipers extend to six inches.

C. Show the five inch vernier caliper that the student will be using. Suggest this as a more appropriate instrument.

D. Use the transparency entitled, "Vernier Caliper," to identify the parts. Point to various parts and have the students identify them.

E. Use transparency entitled, "Vernier Caliper's Beam Scale."

   1. Emphasize that each inch is divided into 20 divisions.

   2. 1" ÷ 20 = .050"

   3. Using the transparency, point to various divisions and have students identify them.

F. Use transparency entitled, "Vernier Caliper's Vernier Scales."

   1. Point out the $\frac{1}{128}$" scale (bottom) and the $\frac{1}{1000}$" scale (top).

   2. Tell the student they will be using only the $\frac{1}{1000}$" (top) scale.

   3. Emphasize that the vernier scale is divided in half.

      a. the bottom half shows .000" to .050"

      b. the top half shows .050" to .100"

      c. point out that the students will only use the bottom part of the vernier scale to obtain readings

   4. Line up the zeros on the "Beam Scale" and the "Vernier Scale."

   5. Point out that 50 divisions on the vernier scale correspond to 2.45" on the beam scale.

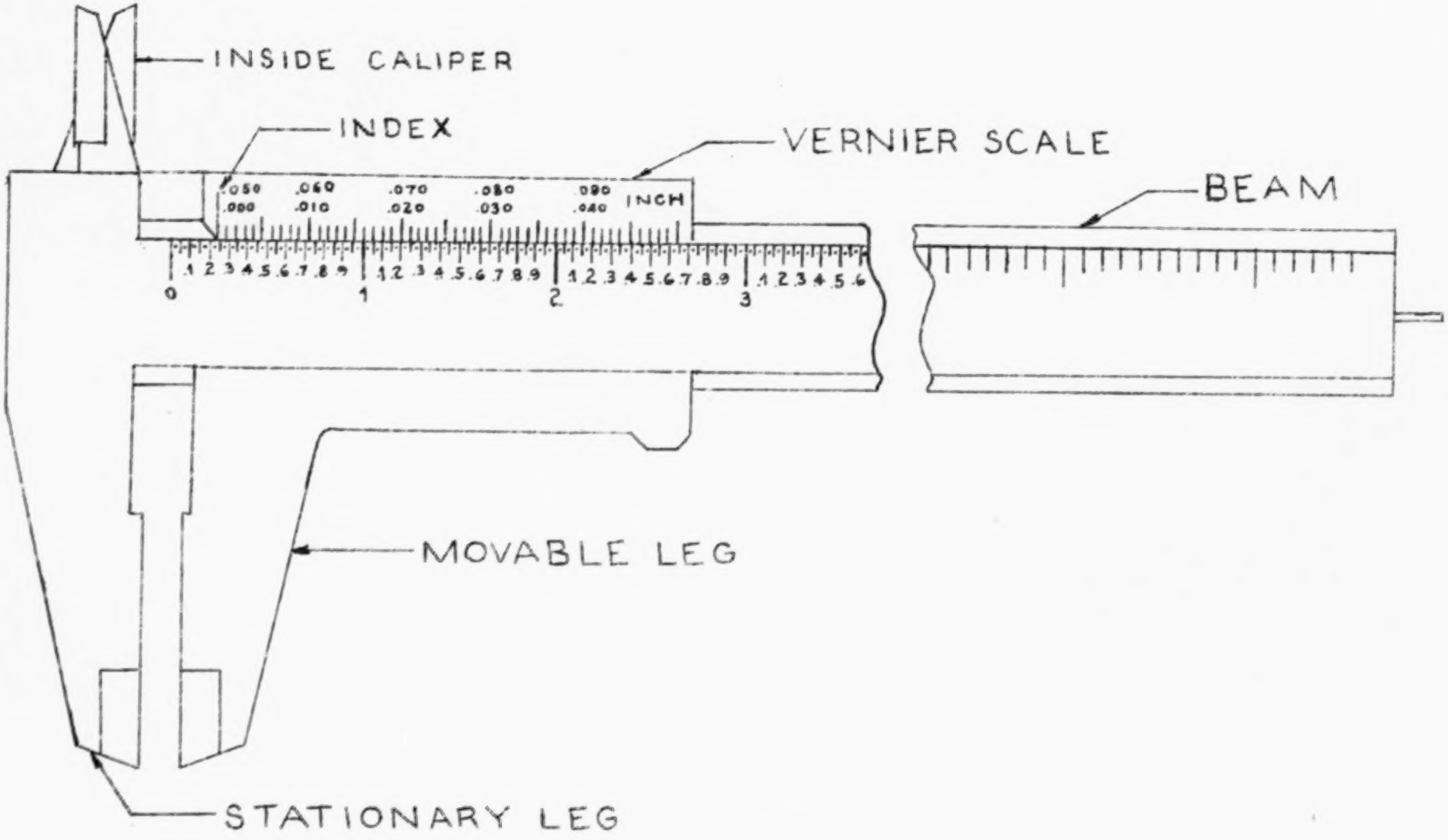
      a. therefore, each space equals $\frac{1}{50} \times 2.45 = .049$"

      b. hence, the difference between a beam scale division and a vernier scale division is .050 - .049 = .001

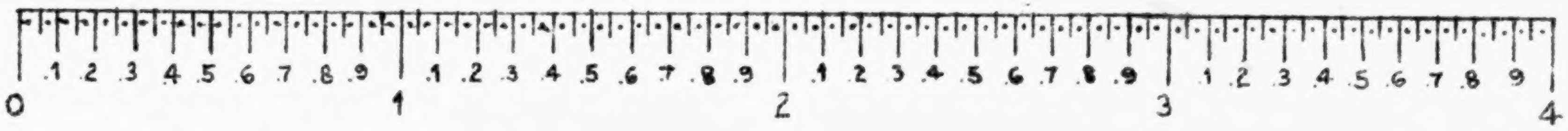
   6. When using vernier calipers actually you do not subtract, there is a short cut.

      a. the zero on the vernier scale is called the "index"

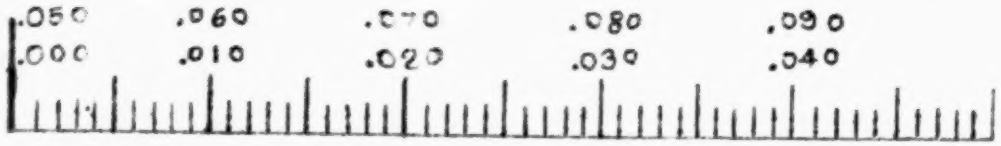
VERNIER CALIPER


INSIDE CALIPER
INDEX
VERNIER SCALE
BEAM
.050 .060 .070 .080 .090
.000 .010 .020 .030 .040
INCH
0
1
2
3
MOVABLE LEG
STATIONARY LEG

VERNIER CALIPER'S BEAM SCALE


.1 .2 .3 .4 .5 .6 .7 .8 .9
.1 .2 .3 .4 .5 .6 .7 .8 .9
.1 .2 .3 .4 .5 .6 .7 .8 .9
.1 .2 .3 .4 .5 .6 .7 .8 .9
0
1
2
3
4

VERNIER CALIPER'S VERNIER SCALE


.050
.000
.060
.010
.070
.020
.080
.030
.090
.040

b. when reading, the index will fall between two lines on the beam. Use the smaller reading.

c. the vernier scale will indicate the number of thousandths to be added to the smaller reading.

    (1) count along the vernier until you reach a line that coincides with a line on the beam

    (2) add the reading which corresponds to that line, to the previously chosen smaller reading

G. Example:

1. The index is between 0.250" and 0.300" on the beam, and line 23 on the vernier coincides with a beam line. What is the reading?

2. Reading = Beam + Vernier
   = .250" + .023" = 0.273"

H. Using both "Vernier Scale" and "Graduated Beam" transparencies slide vernier along beam and have students read various settings.

I. Summary

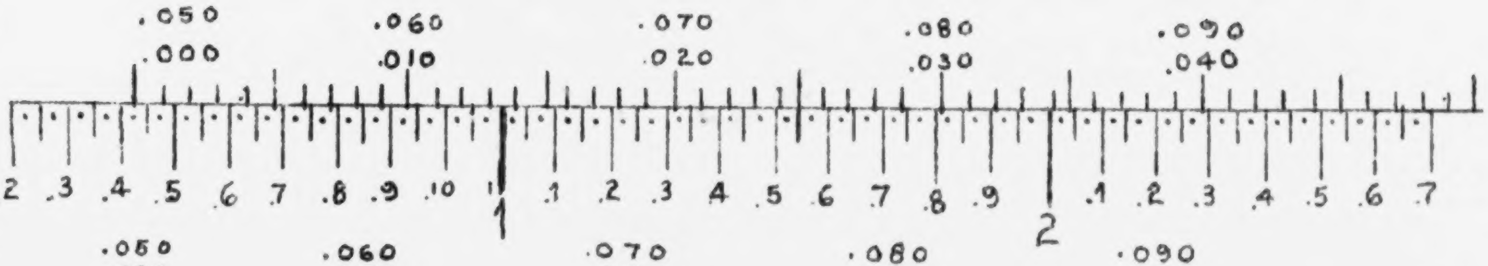
1. Review the parts of vernier calipers.

2. Distribute the work sheet entitled, "Settings for Vernier Calipers." Have students complete this sheet by writing down the indicated setting.

SETTING FOR VERNIER CALIPER

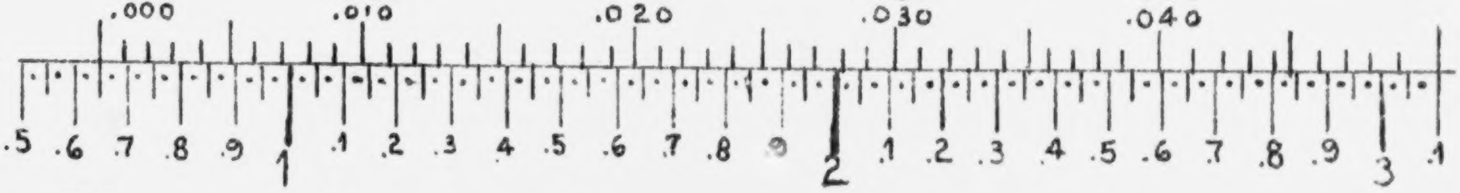
.425

1.


.050 .060 .070 .080 .090
.000 .010 .020 .030 .040
.2 .3 .4 .5 .6 .7 .8 .9 .10 1 .1 .2 .3 .4 .5 .6 .7 .8 .9 2 .1 .2 .3 .4 .5 .6 .7
1
2

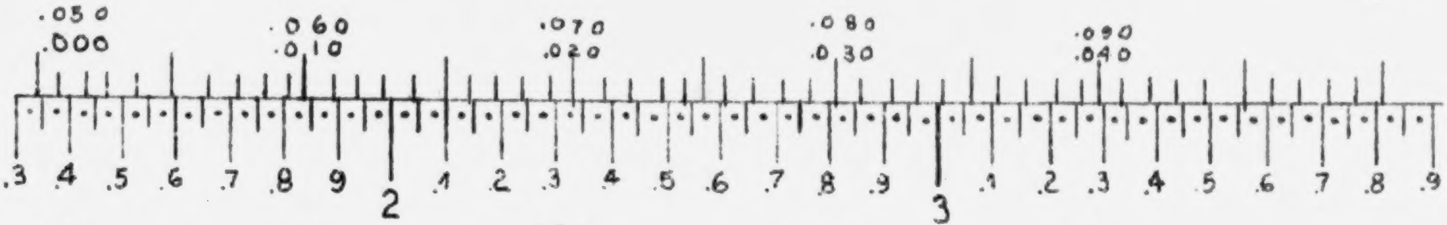
.650

2.


.050 .060 .070 .080 .090
.000 .010 .020 .030 .040
.5 .6 .7 .8 .9 1 .1 .2 .3 .4 .5 .6 .7 .8 .9 2 .1 .2 .3 .4 .5 .6 .7 .8 .9 3 .1

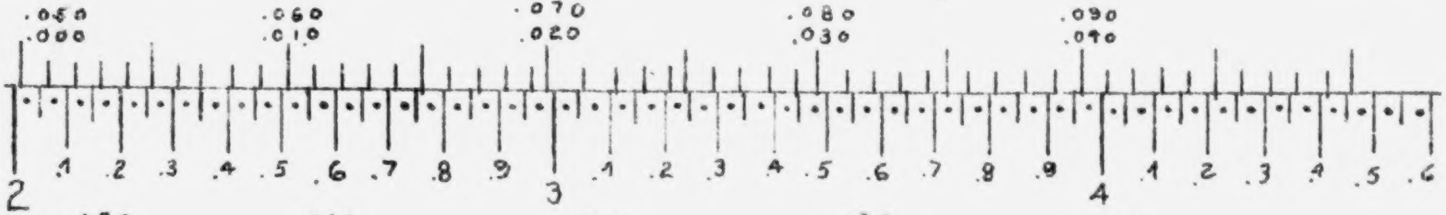
2.130

3.


.050 .060 .070 .080 .090
.000 .010 .020 .030 .040
.3 .4 .5 .6 .7 .8 .9 2 .1 .2 .3 .4 .5 .6 .7 .8 .9 3 .1 .2 .3 .4 .5 .6 .7 .8 .9

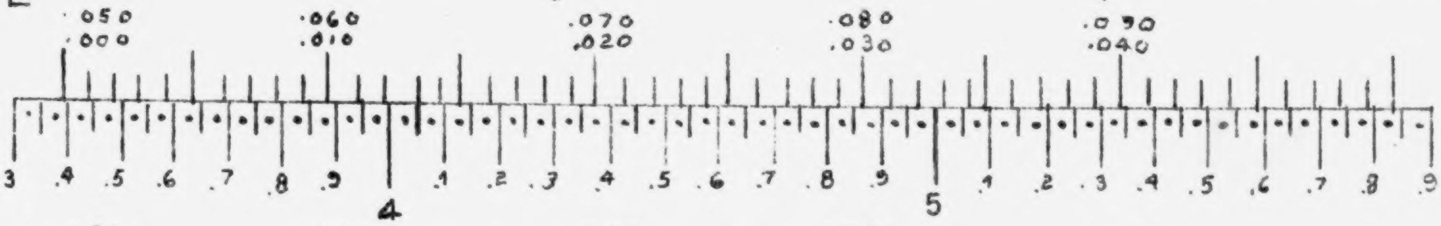
3.047

4.


.050 .060 .070 .080 .090
.000 .010 .020 .030 .040
2 .1 .2 .3 .4 .5 .6 .7 .8 .9 3 .1 .2 .3 .4 .5 .6 .7 .8 .9 4 .1 .2 .3 .4 .5 .6

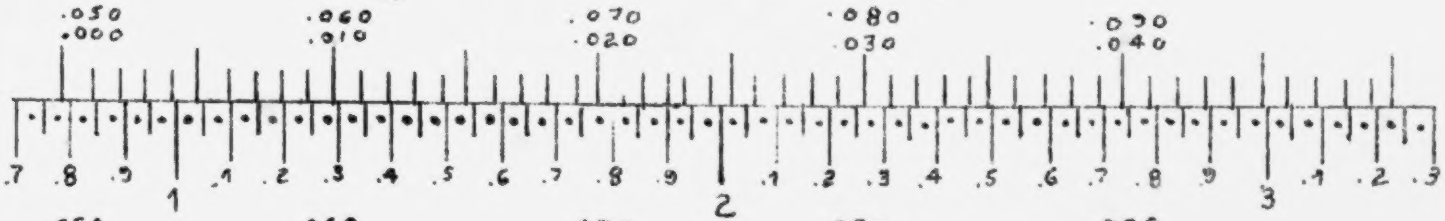
3.362

5.


.050 .060 .070 .080 .090
.000 .010 .020 .030 .040
.3 .4 .5 .6 .7 .8 .9 4 .1 .2 .3 .4 .5 .6 .7 .8 .9 5 .1 .2 .3 .4 .5 .6 .7 .8 .9

.772

6.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.7 .8 .9 1 .1 .2 .3 .4 .5 .6 .7 .8 .9 2 .1 .2 .3 .4 .5 .6 .7 .8 .9 3 .1 .2 .3

4.67

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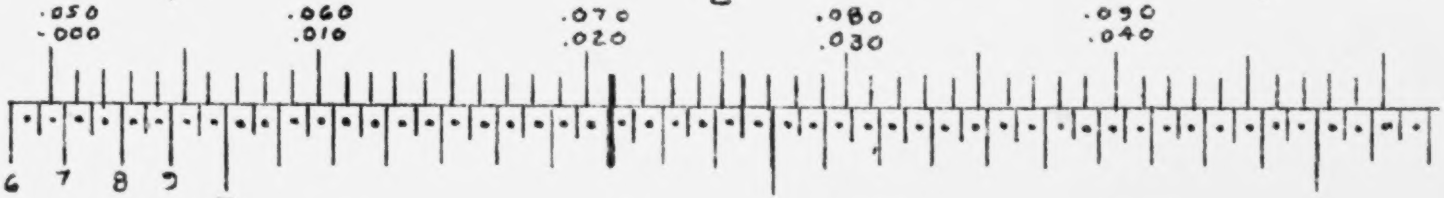
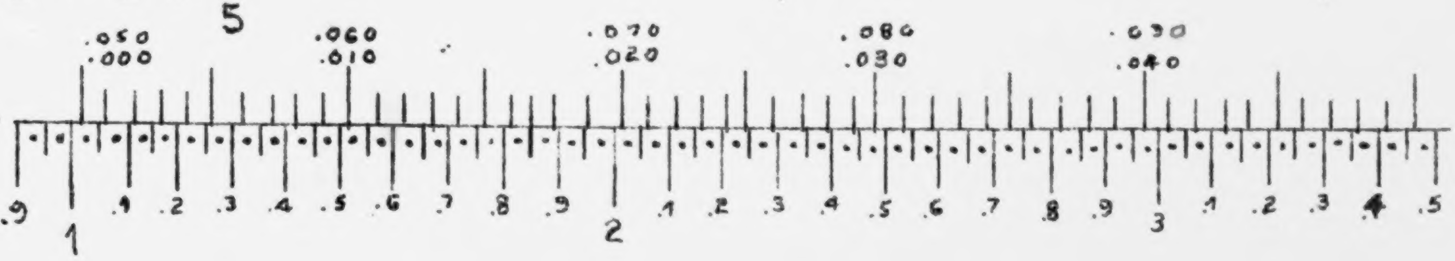

.050 .060 .070 .080 .090
.000 .010 .020 .030 .040
6 7 8 9 5

1.017

8.


.050 .060 .070 .080 .090
.000 .010 .020 .030 .040
.9 1 .1 .2 .3 .4 .5 .6 .7 .8 .9 2 .1 .2 .3 .4 .5 .6 .7 .8 .9 3 .1 .2 .3 .4 .5

I. Activity: Sketching Readings on a Vernier Caliper

II. Objective: The student should be able to sketch a vernier given a specific reading

III. Materials:

A. Several vernier calipers for student use

B. Two work sheets for each student entitled, "Drawing Readings on Vernier Calipers"

IV. Suggested Procedure:

A. Make sure students have completed the work sheet entitled, "Setting for Vernier Caliper." Check their answers.

B. List 32 vernier caliper readings on the board.

1. .131
2. .026
3. .952
4. .736
5. .780
6. .962
7. .512
8. .247
9. .654
10. .868
11. .134
12. .393
13. .103
14. .928
15. .409
16. .310
17. .538
18. .759
19. .875
20. .496
21. .084
22. .760
23. .241
24. .595
25. .476
26. .325
27. .628
28. .375
29. .350
30. .025
31. .404
32. .144

C. Hand out work sheets entitled, "Drawing Readings on Vernier Calipers" (two per sutdent).

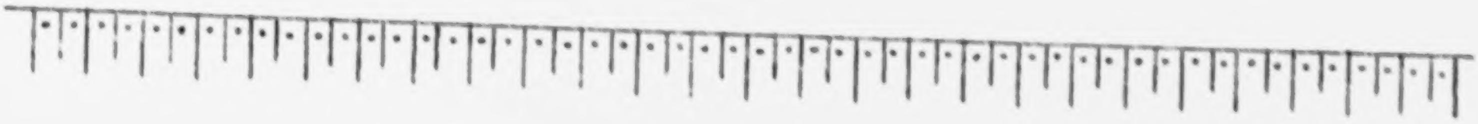
D. Hand out vernier calipers available for use.

E. Have student represent readings on board on the vernier calipers.

1. Number the beam
2. Use an arrow labeled "0" to point where index would be.
3. A second arrow will be placed to indicate where the beam and vernier scales coincide. This arrow can be located as follows:
    a. Subtract the reading on the beam to the left of the index from the desired reading.
    b. This difference indicates the number of lines to the right of the index to which the second arrow will point.

DRAWING READINGS
ON
VERNIER CALIPERS

1.



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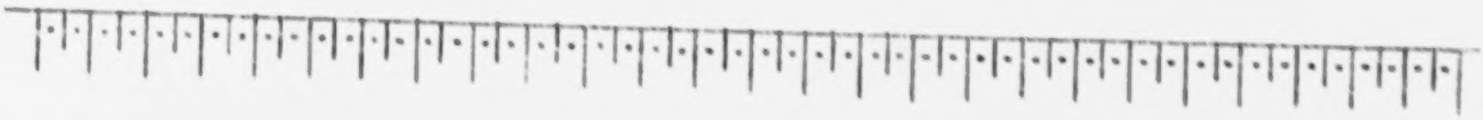

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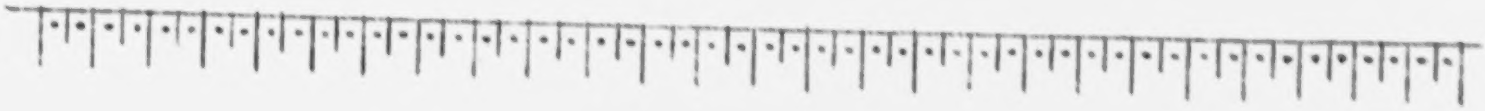

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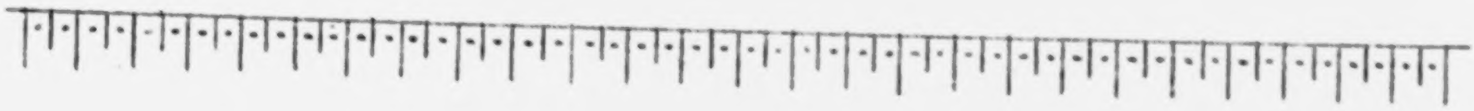

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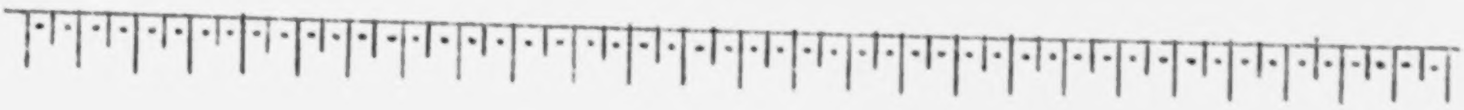

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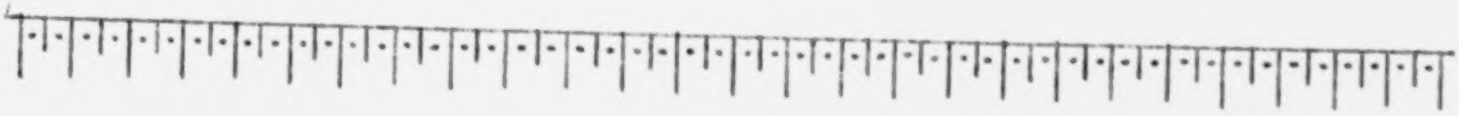

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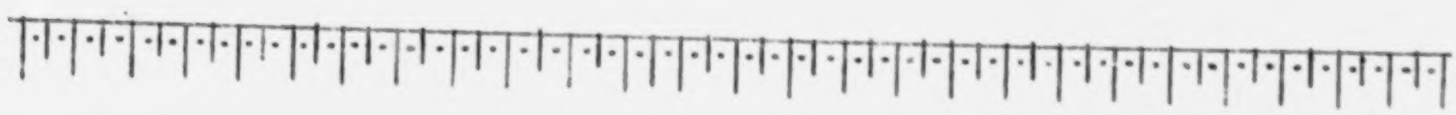

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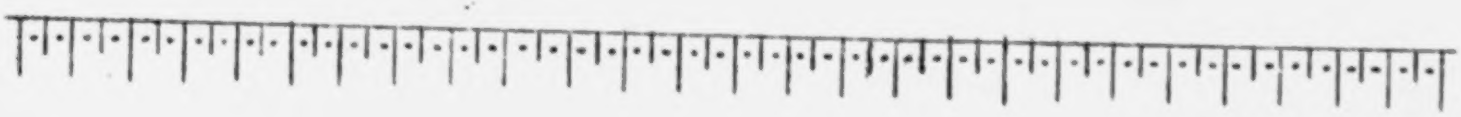


I. Activity: Measuring with a Vernier Caliper

II. Objective: The student should be able to:

Measure various objects with a vernier caliper

III. Materials:

- A. Several vernier calipers for student use
- B. One vernier caliper kit

IV. Suggested Procedure:

- A. Make sure students have completed the work sheet entitled, "Drawing Readings on Vernier Calipers."
- B. Hand out vernier calipers.
- C. Have students number on a sheet of paper 1-30.
- D. Use a laboratory approach.
  - 1. Place objects around room.
  - 2. Let students measure each object, they do not have to do them in order.
  - 3. Remind them to record each measurement.
  - 4. Other possible approaches are given in the unit entitled, "Steel Scale."

V. Suggested Evaluation for The Vernier Caliper

- A. Have students identify readings on a vernier caliper.
- B. Have students draw readings on a vernier caliper.
- C. Have students draw and label a vernier caliper.
- D. Hand out vernier calipers before test.

  During test there will be five numbered items to be measured and recorded on test paper.

I. Activity: Inside Caliper

II. Objective: The student should be able to:

Obtain measurements using an inside caliper

III. Background Information:

Before attempting this unit make sure the student can read a steel scale, a micrometer, and a vernier caliper

IV. Materials:

A. One inside caliper for each student

B. One "Inside and Outside Caliper" kit

C. One steel scale for each student

D. One micrometer for each student

E. Several vernier calipers for student use

F. One work sheet for each student entitled, "Inside Calipers"

V. Suggested Procedure:

A. Show an inside caliper.

B. Demonstrate how to measure inside diameter of a piece of tubing.

C. Show the proper technique for placing the caliper against a scale to obtain reading.

1. Take scale and stand it on one end on desk.
2. Place inside caliper against scale with one point on desk and other along scale and read measurement on scale.

D. Show the proper technique for placing the inside caliper in a micrometer.

1. Place caliper between anvil and spindle--rotate thimble slowly until spindle touches caliper.
2. If any pressure is exerted on caliper the reading will be affected.

E. Show the proper technique for placing the inside caliper in the vernier caliper.

  Place the inside caliper between the stationary leg and the moveable leg and close slowly.

F. When working with kit, use a laboratory approach as explained in the unit on the steel scale.

G. Hand out work sheet and have students measure the inside diameter of each piece of tubing. They should record measurements using the scale, micrometer, vernier caliper.

INSIDE CALIPER

Directions: Measure the inside of each tube with your inside calipers. Then place it against a scale, within a micrometer and vernier caliper and record readings.

Tube Label	Scale Measurement	Micrometer Measurement	Vernier Caliper Measurement

I. Activity: Outside Caliper

II. Objective: The student should be able to:

Obtain a reading using an outside caliper

III. Materials:

A. One outside caliper for each student

B. One steel scale for each student

C. Transparency of six inch steel scale

D. One kit entitled, "Inside and Outside Caliper"

IV. Suggested Procedure:

A. Show an outside caliper.

B. Demonstrate how to measure the outside diameter of a piece of tubing.

C. Show the proper technique for placing the caliper against a scale to obtain a reading.

1. Place the tip of one leg of the caliper against the end of a scale and obtain the measurement at the other leg.

2. Use the transparency of six inch scale to project measurement and to help with readings.

D. Use a laboratory approach as explained in steel scale unit with the inside and outside caliper kit.

E. Hand out work sheet entitled, "Outside Caliper."

1. Have students measure each object and complete column entitled, "Outside Diameter."

2. Tell the student to complete the column entitled, "Inside Diameter" using measurement recorded on the "Inside Caliper" work sheet under the scale measurement column.

3. The column entitled, "2T" is completed by finding the difference between the outside diameter and inside diameter, i.e. O.D. - I.D. = 2T

OUTSIDE CALIPER

Directions: Find the outside diameter of each piece of tubing using the steel scale and outside calipers.

Tube Label	Outside Diameter O. D.	Inside Diameter I. D.	2T O. D. - I. D.	T Wall Thickness

I. Activity: Types of Threads

II. Objectives: The student should be able to:

  A. Name and identify various types of threads

  B. Name and identify various parts of threads

III. Background Information:

  Read introduction to "Screw Threads" in textbook, pages 397-398

IV. Materials:

  A. A transparency with various types of threads

    1. Sharp "V"

    2. National

    3. Whitworth

    4. Unified

    5. American Acme

    6. Stub Acme

    7. Square

    8. Buttress

  B. Two bolts from kit entitled, "Threads"

    1. Left hand bolt with nut

    2. Right hand bolt with nut

  C. Transparency entitled, "Parts of a Thread"

  D. Kit entitled, "Threads"

  E. A work sheet for each student entitled, "Threads"

V. Suggested Procedure:

  A. Show the difference between right hand threads and left hand threads.

    1. Use two bolts from kit

    2. Let a student attempt to put a nut on each

a. a nut turns clockwise going on a right handed thread

b. a nut turns counter-clockwise going on a left handed thread

B. Use the transparency with various types of thread.

1. Point out various angles between threads.

2. Point out basic differences in design of threads, flat, square, pointed.

3. The National thread or American Standard thread or The American National thread are the most commonly used today in the United States.

C. Use the transparency with parts of a thread. Be sure to point out the root, crest, pitch, and flank of a thread.

D. When working with the kit, use a laboratory approach as explained in the unit on the steel scale.

1. Have students identify each bolt as having a left-handed thread or a right-handed thread.

2. Have students record answer on work sheet. The columns entitled, "Number of Threads/Inch" and "Pitch" will be completed later.

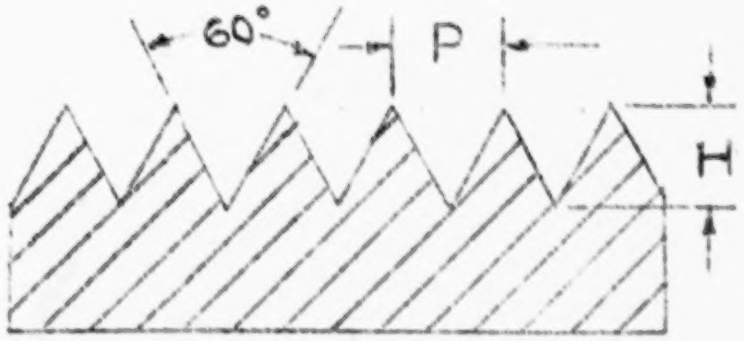
3. Since the kit does not have a nut for each bolt have the student rotate bolt clockwise and counter-clockwise to identify right and left hand threads.

a. Hold each bolt with head in left hand

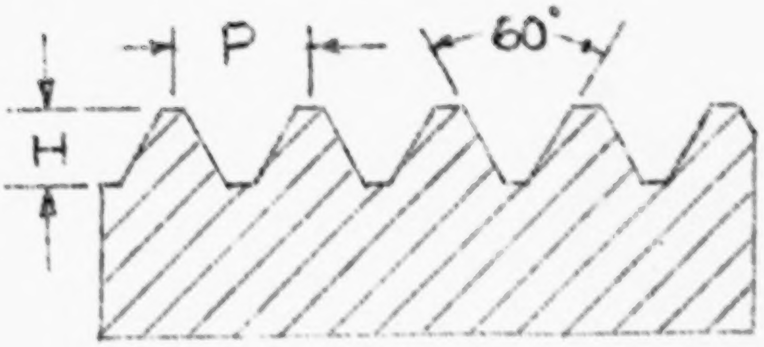
b. If you rotate a bolt toward you (counter-clockwise) and the thread moves inward (toward the head of the bolt) it is a right-hand thread

c. If you rotate a bolt away from you (clockwise) and the thread moves outward (away from the head) it is a left-hand thread

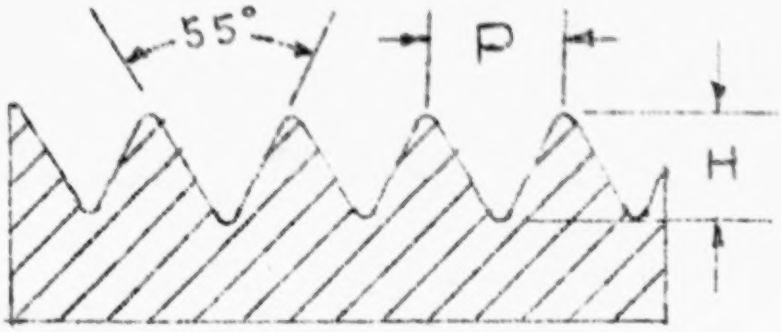
STANDARD THREAD FORMS



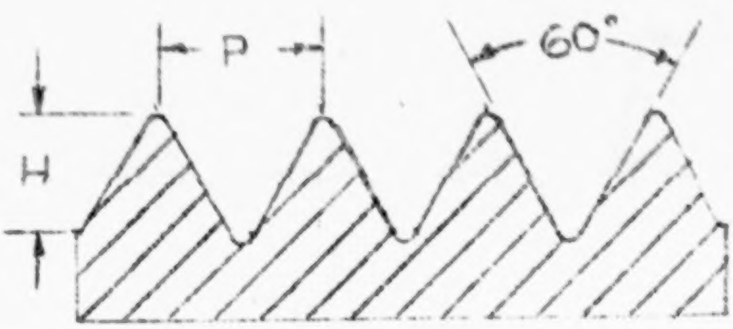
SHARP "V" THREAD



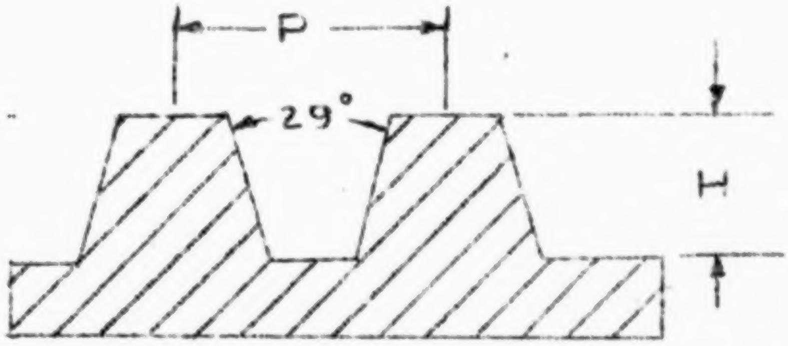
NATIONAL THREAD



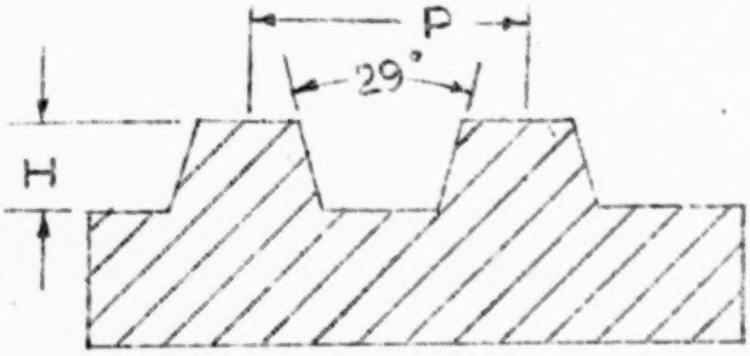
WHITWORTH THD.



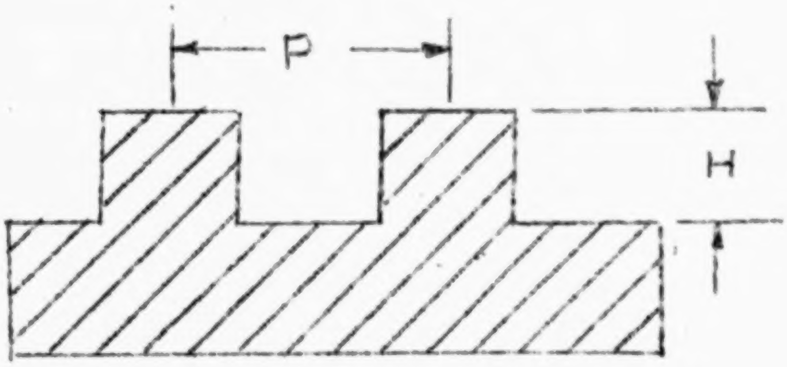
UNIFIED THREAD



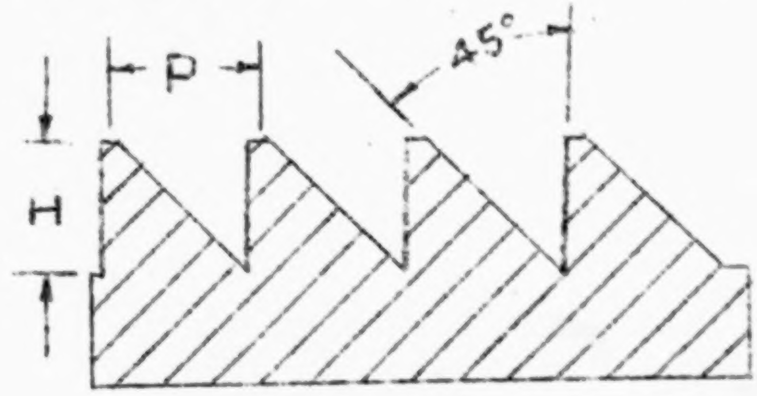
AMERICAN ACME THD.



STUD ACME THD.

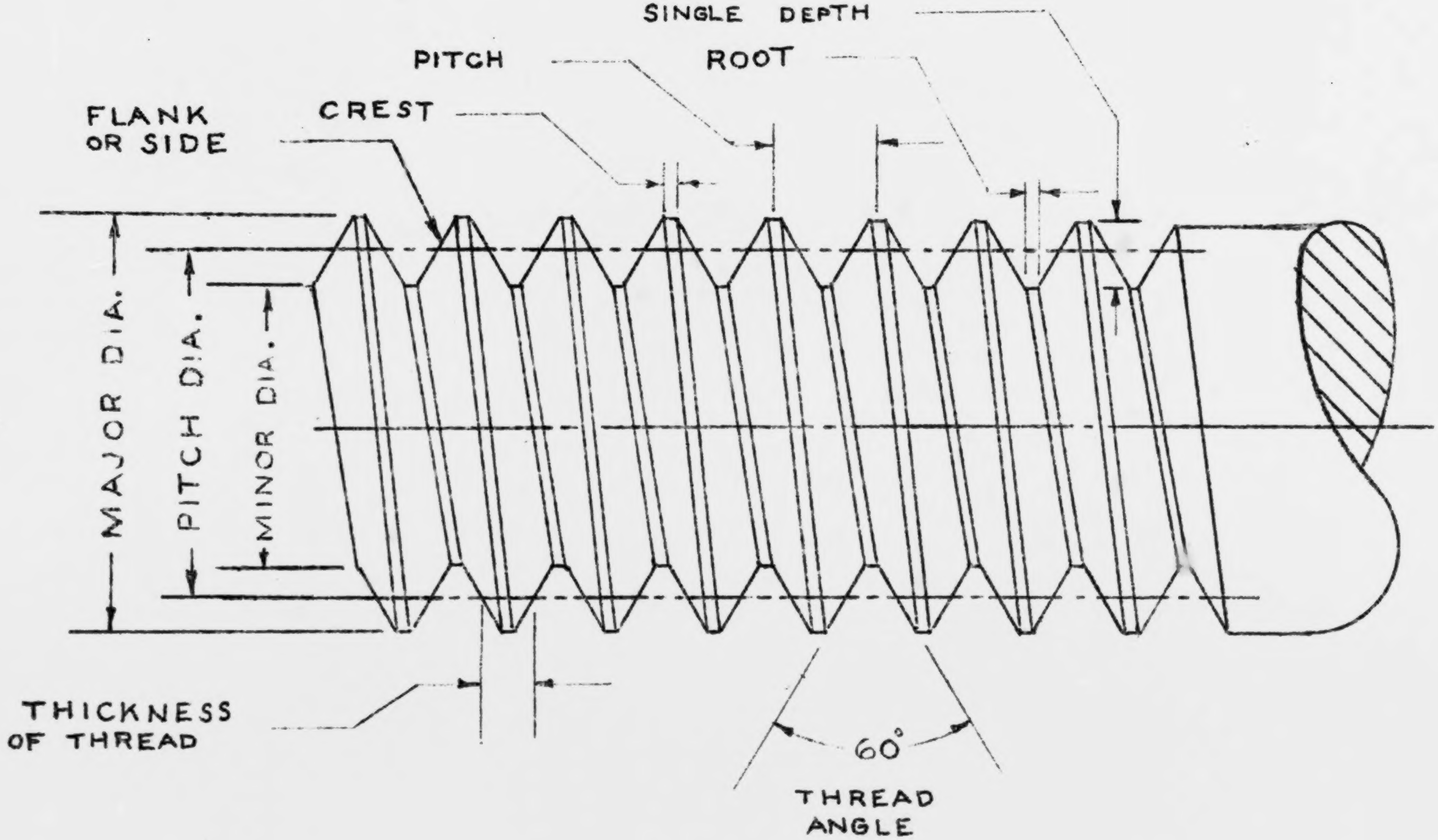


SQUARE THREAD



BUTTRESS THD.

PARTS OF A THREAD


SINGLE DEPTH
PITCH
ROOT
FLANK OR SIDE
CREST
MAJOR DIA.
PITCH DIA.
MINOR DIA.
THICKNESS OF THREAD
60°
THREAD ANGLE

THREADS

Directions: Complete only the column labeled right and left hand threads.

Bolt Label	Thread R.H. or L.H.	Number of Threads/Inch	Pitch (Measured)	Pitch (Formula) $P = \frac{1}{n}$
1				
2				
3				
4				
5				
9				
10				

I. Activity:. Number of Threads Per Inch

II. Objectives: The student should be able to:

Find the number of threads per inch using a six inch steel scale

III. Materials:

A. Kit entitled, "Threads"

B. Steel scale for each student

C. Overhead projector

IV. Suggested Procedure:

A. From the kit take the bolt with the largest threads.

B. Place the transparency of "Six Inch Scale" and the bolt on overhead.

1. Line the crest of one thread with an inch mark

2. Count the number of crests per inch and subtract one. This will be the number of threads per inch

C. Hand out steel scales.

D. When working with the kit, use a laboratory approach as explained in the unit on the steel scale.

E. Have students complete the column headed "Number of Threads/Inch" on the work sheet entitled, "Threads."

I. Activity: Pitch

II. Objectives: The student should be able to:

A. Find the pitch by measuring the distance between threads

B. Find the pitch by formula

III. Materials:

A. Steel scale for each student

B. Kit entitled, "Threads"

C. Transparency entitled, "Parts of Threads"

D. Textbook

IV. Suggested Procedure:

A. Use transparency to show that pitch is the distance between threads.

B. Use page 401 in textbook to illustrate pitch.

C. Emphasize that pitch can be measured with a scale.

1. Fine threads are very difficult to measure because of closeness

2. A simple formula makes finding pitch easier ($P = \frac{1}{N}$) where N equals number of threads per inch

D. Have students complete the columns headed "Pitch (Measured)" and "Pitch (Formula $P = \frac{1}{N}$) on the work sheet entitled, "Threads."

I. Activity: Diameters in Threads

II. Objectives: The student should be able to:

- A. Find the major diameter in threads
- B. Find the minor diameter in threads
- C. Find the pitch diameter in threads
- D. Interpret the nomenclature of a bolt

III. Materials:

- A. Transparency entitled, "Parts of Threads"
- B. Work sheet for each student entitled, "Thread Data"

IV. Suggested Procedure:

A. Use transparency entitled, "Parts of Threads" to point out major diameter, minor (root) diameter, and pitch diameter.

B. Show how bolts and screws are specified.

1. The nominal size (major diameter)
2. The number of threads per inch
3. The thread-screw designation
    - a. Unified thread abbreviated, "UN"
    - b. V-thread abbreviated "V"
    - c. American National abbreviated "N"

C. The depth of National thread (h_s) is equal to .64952 divided by number of threads per inch

$$h_s = \frac{.64952}{n}$$

D. The pitch diameter (E_s) is equal to outside diameter (D) minus the thread depth (h_s).

$$E_s = D - h_s$$

$$E_s = D - \frac{.64952}{n}$$

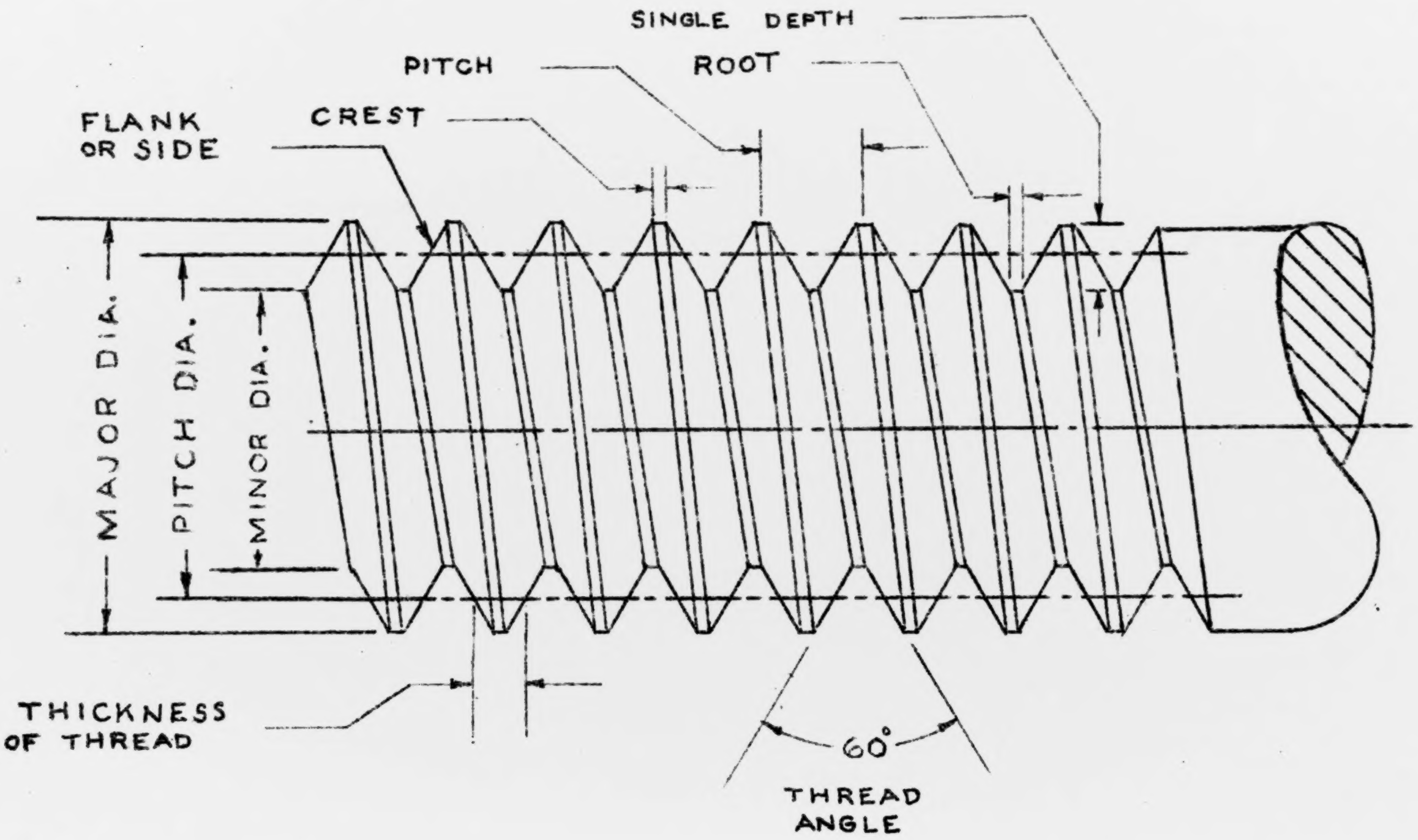
E. The minor diameter (K_s) is equal to outside diameter (D) minus twice the thread depth ($2 \cdot h_s$).

$$K_s = D - 2 \cdot h_s$$

F. Show the student how to work the first two problems on the work sheet. Do not emphasize memorizing the formulas!

G. Hand out work sheet entitled, "Thread Data" and have students complete it.

PARTS OF A THREAD


SINGLE DEPTH
PITCH
ROOT
FLANK OR SIDE
CREST
MAJOR DIA.
PITCH DIA.
MINOR DIA.
THICKNESS OF THREAD
60°
THREAD ANGLE

THREAD DATA

Directions: Complete each of the following columns.

Bolt	Major Diameter	Number of Threads/Inch	Pitch $P = \frac{1}{n}$	Thread Depth $h_s = \frac{.64952}{n}$	Pitch Diameter $E_s = D - h_s$	Minor Diameter $K_s = D - 2h_s$
$\frac{3}{4}$" - 10 NC	.750	10	$P = \frac{1}{10}$ $P = .100$	$h_s = \frac{.64952}{10}$ $h_s = .064952$	$E_s = .750 - .064952$ $E_s = .685048$	$K_s = .750 - 2(.064952)$ $K_s = .620096$
$\frac{1}{4}$" - 20 NC						
1" - 14 NF						
$\frac{9}{16}$" - 18-NF						
2" - 4 - NC						
$\frac{7}{16}$" -18-NC						
$\frac{3}{8}$" -20-NC						
$\frac{1}{2}$" -15-NC						
$1\frac{1}{4}$" -10-NF						

I. Activity: Tap Drill

II. Objectives: The student should be able to:

Apply a formula to determine the appropriate size tap drill necessary for a given bolt

III. Background Information:

A. The tool used to form the internal threads, after the hole has been drilled, is called a tap drill. The tap drill size depends on many factors such as material, speed of drill, per cent of full threads and threadpitch. A full thread is unnecessary for strength and is extremely costly. Industry through experience uses about 80 per cent full thread down to 50 per cent. On this basis a simple working formula for tap drill size (T) is: T = D - (per cent of full thread) x 2 x h_s (thread depth).

B. For related problems consult the textbook, pages 414-425.

IV. Materials:

A work sheet for each student entitled, "Tap Drill Size"

V. Suggested Procedure:

A. Discuss tap drills and their purpose as explained in the background information. Further information can be found on pages 415-419 of textbook.

B. Work the following examples:

1. What size tap drill is necessary for drilling a hole for a $\frac{1}{2}$" - 20 NC if 75% of full thread is necessary?

$$
\begin{aligned}
T &= .D - .75 \times 2 \times h_s \\
&= .500 - .750 \times 2 \times \frac{.64952}{20} \\
&= .500 - .048714 \\
T &= .451286 \approx .451
\end{aligned}
$$

2. What size tap drill is necessary for drilling a hole for a $\frac{3}{4}$" - 10 NC if 80% of full thread is necessary?

$$T = .750 - .80 \times 2 \times \frac{.64952}{10}$$

$$T = .750 - .1039232$$

$$T = .7460768 \cong .746$$

C. If 77% full thread is desired, the formula simplifies to:

$$T = D - \frac{1}{n}$$

D. Hand out work sheet and have the students complete it.

VI. Suggested Evaluation:

A. Threads

1. Identify various types of threads from drawings.
2. Identify various parts of a thread.
3. Have problems similar to those on work sheet. Provide formulas where necessary.

B. Have problems similar to those on tap drill work sheet.

TAP DRILL SIZE

Directions: For each bolt find the tap drill size for the percent of thread indicated. The basic formula is:

$$T = D - (\text{per cent of full thread} \times 2 \times h_s.$$

Bolt	75% Full Thread	50% Full Thread $T = D - \frac{1}{n}$	77% Full Thread
$\frac{3}{4}$" - 10 NC			
$\frac{1}{4}$" - 20 NC			
1" - 14 NF			
$\frac{9}{16}$" -18-NF			
2" - 4 - NC			
$\frac{7}{16}$" -18-NC			
$\frac{3}{8}$" - 20 NC			
$\frac{1}{2}$" -15 NC			
$1\frac{1}{4}$"-12-NF			

I. Activity: Finding Tolerances

II. Background Information:

Read page 405 in textbook

III. Objectives: The student should be able to:

A. Compute upper and lower limits

B. Find tolerances when working with decimals

C. Distinguish between unilateral and bilateral tolerances

IV. Materials:

A work sheet entitled, "What's the Tolerance?"

V. Suggested Procedure:

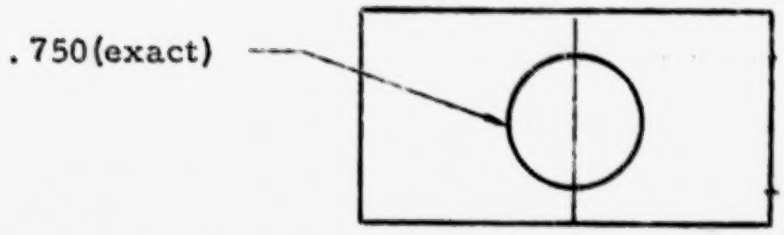
A. Use background information as a motivation

B. Ask--"What is tolerance?" Tolerance is the total permissible variation of a size.

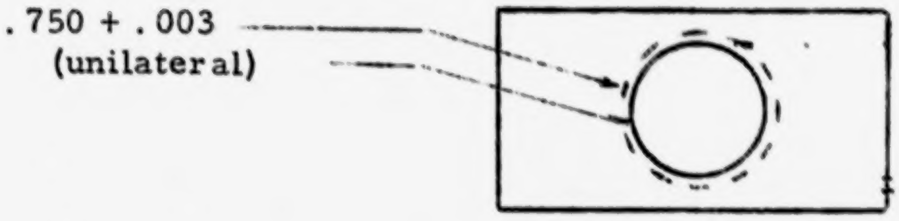
C. Explain the difference between unilateral and bilateral tolerance.

1. Make drawings on the board of the following:

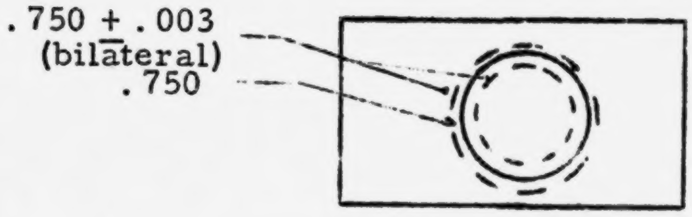
a.



b.



c.



d. The first drawing is of a piece of metal with a hole to exactly .750. Drilling to an exact dimension is very costly to industry.

e. The second drawing represents unilateral tolerance which is either plus or minus, not both.

f. The third drawing illustrates bilateral tolerance which is both plus and minus.

D. Hand out work sheet entitled, "What's the Tolerance." Go over the first problem with the class. Let the students complete the work sheet.

WHAT'S THE TOLERANCE

Directions: Find the upper limit, the lower limit, and the tolerance. The first one has been done for you.

Size of Machine Part	Upper Limit	Lower Limit	Tolerance U. L. - L. L. = T
1. .375 ± .002	.377	.373	.004
2. .159 ± .003			
3. .378 ± .016			
4. .597 ± .087			
5. .736 ± 173			
6. .925 ± .034			
7. .214 ± .011			
8. .483 + .128			
9. .652 + .075			
10. .841 + .006			
11. .360 - .059			
12. .579 - .070			
13. .731 - .039			
14. .132 ± .041			
15. .113 ± .022			
16. .124 - .013			
17. .165 + .035			
18. .196 - .026			
19. .987 + .017			
20. .378 + .032			

I. Activity: Fractional Tolerance

II. Objectives: The student should be able to:

Find tolerance when working with fractions

III. Materials:

Work sheet for each student entitled, "Fractional Tolerance"

IV. Suggested Procedure:

A. Review ideas concerning tolerance.
B. Hand out work sheet.
C. Have students complete columns.

FRACTIONAL TOLERANCE

Directions: Find the upper limit, the lower limit, and the tolerance. The first one has been done for you.

Size of Machine Part	Upper Limit	Lower Limit	Tolerance U. L. - L. L. = T
1. $1\frac{1}{8} \pm \frac{1}{16}$	$1\frac{3}{16}$	$1\frac{1}{16}$	$1\frac{3}{16} - 1\frac{1}{16} = \frac{1}{8}$
2. $1\frac{1}{4} \pm \frac{1}{8}$			
3. $1\frac{5}{16} \pm \frac{3}{16}$			
4. $1\frac{9}{16} \pm \frac{1}{4}$			
5. $2\frac{7}{32} \pm \frac{1}{32}$			
6. $4\frac{5}{8} \pm \frac{5}{32}$			
7. $3\frac{9}{64} \pm \frac{1}{64}$			
8. $5\frac{63}{64} + \frac{5}{32}$			
9. $7\frac{1}{2} + \frac{7}{16}$			
10. $8 - \frac{1}{32}$			
11. $4\frac{7}{16} - \frac{1}{16}$			
12. $2\frac{11}{16} + \frac{1}{8}$			
13. $1 - \frac{3}{16}$			
14. $\frac{5}{16} \pm \frac{1}{64}$			
15. $\frac{7}{8} \pm \frac{1}{64}$			
16. $\frac{15}{16} \pm \frac{1}{16}$			
17. $\frac{35}{64} \pm \frac{1}{32}$			
18. $1\frac{31}{32} + \frac{3}{64}$			
19. $1 - \frac{1}{16}$			
20. $1\frac{3}{8} + \frac{1}{16}$			

I. Activity: Applying Tolerance

II. Objectives: The student should be able to:

Apply the concept of tolerance to an inspecting situation

III. Materials:

A work sheet entitled, "Inspector"

IV. Suggested Procedure:

A. Hand out work sheet and discuss.

B. Define "rework" as applying to a piece that can be done over.

C. Define "reject" as applying to a piece that can not be done over.

D. Define "ok" as applying to a piece that meets the prescribed tolerance.

INSPECTOR

Directions: Your job is to evaluate each of the following machine parts and decide whether to reject it, rework it, or ok it.

Desired Size of Hole	Actual Size of Hole Measured	Reject	Rework	Ok
1. .375 ± .002	.378			
2. .159 ± .003	.160			
3. .378 ± .016	.350			
4. .597 ± .087	.511			
5. .736 ± .173	.740			
6. .925 ± .034	.901			
7. .214 ± .011	.235			
8. .483 + .128	.475			
9. .652 + .075	.695			
10. .841 + .006	.835			
Desired Size of Shaft	Actual Size of Shaft Measured			
11. .360 ± .059	.300			
12. .579 ± .070	.580			
13. .731 ± .039	.775			
14. .132 ± .041	.152			
15. .113 ± .022	.143			
16. .342 ± .013	.364			
17. .675 + .045	.615			
18. .896 + .017	.886			
19. .327 - .021	.328			
20. .283 - .016	.245			

I. Activity: Tolerance

II. Objective: The student should be able to:

Add and subtract fractions related to a situation dealing with tolerances

III. Materials:

A work sheet for each student entitled, "Fractional Inspector"

IV. Suggested Procedure:

A. Hand out work sheet.

B. Have students complete work sheet.

V. Evaluation:

Make up test incorporating problems similar to work sheet.

FRACTIONAL INSPECTOR

Directions: You are an inspector and will have the job of evaluating the following machine parts.

Desired Size of Hole	Actual Size of Hole Measured	Reject	Rework	Ok
1. $1\frac{1}{8} \pm \frac{1}{16}$	$\frac{15}{16}$			
2. $1\frac{1}{4} \pm \frac{1}{8}$	$1\frac{3}{8}$			
3. $1\frac{5}{16} \pm \frac{3}{16}$	$1\frac{1}{4}$			
4. $1\frac{9}{16} \pm \frac{1}{4}$	$1\frac{3}{16}$			
5. $2\frac{7}{32} \pm \frac{1}{32}$	$2\frac{3}{8}$			
6. $4\frac{5}{8} \pm \frac{5}{32}$	$4\frac{7}{8}$			
7. $3\frac{9}{64} \pm \frac{1}{64}$	$3\frac{1}{8}$			
8. $5\frac{63}{64} + \frac{5}{32}$	$5\frac{25}{32}$			
9. $7\frac{1}{2} + \frac{7}{16}$	$7\frac{3}{4}$			
10. $8 - \frac{1}{32}$	$7\frac{63}{64}$			

Desired Size of Shaft	Actual Size of Shaft Measured	Reject	Rework	Ok
11. $4\frac{7}{16} \pm \frac{1}{16}$	$4\frac{1}{2}$			
12. $2\frac{11}{16} \pm \frac{1}{8}$	$2\frac{5}{8}$			
13. $1 \pm \frac{3}{16}$	$1\frac{3}{64}$			
14. $\frac{5}{16} \pm \frac{1}{64}$	$\frac{1}{4}$			
15. $1\frac{7}{8} \pm \frac{5}{64}$	$1\frac{1}{2}$			
16. $\frac{15}{16} \pm \frac{1}{8}$	$5\frac{1}{64}$			
17. $1\frac{35}{64} \pm \frac{3}{32}$	$1\frac{17}{32}$			
18. $1\frac{31}{32} + \frac{3}{64}$	$1\frac{65}{64}$			
19. $1\frac{3}{8} + \frac{1}{16}$	$1\frac{1}{2}$			
20. $2\frac{3}{64} - \frac{5}{16}$	$1\frac{1}{8}$			

I. Activity: Surface Speed

II. Objectives: The student should be able to:

Apply formulas to find:

1. surface speed or cutting speed (S)
2. speed of a motor (R)
3. the diameter of a tool (D)

III. Background Information:

A. Pages 340-341 in the textbook.

B. Surface speed is a critical financial factor in industry today. A machinist operating a machine at incorrect surface speed could be injured, ruin the tool, lose time, or ruin the material. These occurrences in turn mean loss of money and profit. On the other hand, a good machinist can increase profits by running the machine at the correct speed.

Surface speed can easily be mastered by students without any algebra or any geometry. It involves three formulas using multiplication and division.

IV. Materials:

A. Work sheet entitled, "Surface Speed Data"

B. Textbook, pages 340-344

V. Suggested Procedure:

A. Discuss the ideas of surface speed as explained in the text.

B. Work example problems from the textbook, pages 342-344.

C. Hand out work sheet.

D. Have problems 1, 4, and 7 worked at the board and explained.

E. Have students complete work sheet.

SURFACE SPEED DATA

Directions: Complete each of the following columns using:

(1) $D = \frac{12S}{\pi RPM}$ to find diameter

(2) $RPM = \frac{12S}{\pi D}$ to find RPM's

(3) $S = \frac{\pi \cdot D \cdot RPM}{12}$ to find surface speed

Number	Diameter	RPM	Surface Speed (F. P. M.)
1	15 in.	1200	
2	5 in.	400	
3	6 in.	600	
4		240	4400
5		10,000	50
6		100	50
7	$\frac{1}{2}$ in.		60
8	12 in		40
9	$\frac{1}{4}$ in.		80
10	$2\frac{1}{2}$ in.	150	
11	10 in.	1440	
12	12 in.		2512
13		1728	942
14	7 in.		45
15	5 in.	70	

I. Activity: Surface Speed--Word Problems

II. Objectives: The student should be able to:

Solve word problems involving surface speed, rpm, and the diameter of a tool

III. Materials:

Textbook, pages 344-347

IV. Suggested Procedure:

A. Check work sheet entitled, "Surface Speed Data."

B. Have students read problem #1 on page 344 silently. Then have a student read it aloud.

C. Have students decide what is given and list it on the board.

D. Have students decide what is unknown and which formula they would use to find it.

E. Follow same procedure when working problems #4, 9 on page 344 on the board.

I. Activity: Cutting Speed

II. Objectives: The student should be able to:

A. Find the cutting speed from a table for various metal and materials

B. Find cutting speed, diameter of tool and rpm of motor using the following short formulas:

$$C = \frac{dR}{4} \qquad R = \frac{4C}{d} \qquad d = \frac{4C}{R}$$

where C = cutting speed
d = diameter of tool
R = rpm

III. Background Information:

A. Since there are many factors affecting cutting speed in various metals, a slight variation of speeds is permissible. This variation can be seen in the short formulas where $\pi \approx 3$.

B. Surface speed is referred to as cutting speed (C) when we are working with revolving cutting tools or revolving metal stock. Explain this to the students.

IV. Materials:

A. Chart for each student entitled, "Table of Cutting Speeds for Various Machine and Materials"

B. Transparency of "Cutting Speed Chart"

C. Student work sheet entitled, "Cutting Speed Data"

V. Suggested Procedure:

A. Review the formulas from the lessons on Surface Speed. Show the students how the short formula is derived by using 3 as an approximation of π.

B. Work an example problem using each formula in short form.

C. Show and explain to the students the table using transparency entitled, "Table of Cutting Speeds for Various Machines and Materials."

D. Give each student a copy of the table of cutting speeds.

E. Hand out the work sheet and work the first and second problem with the class.

   1. Since the chart has upper limit and lower limit for cutting speed, use upper limit for problems.

   2. Tell the students that tool steel can be cut only when annealed (softened).

F. After work sheet has been completed, have students compare answers to problems Nos. 2, 5, 7, 12, 15, and 16 with the table of cutting speeds.

   1. The table was prepared not by formulas, but through experimentation in industry.

   2. Ask them which would they use--the table or the formula?

TABLE OF CUTTING SPEEDS FOR VARIOUS MACHINES AND MATERIALS

Materials to be Cut	Machine Used	High-Speed Steel Tool (f. p. m.)	Carbon Steel Tools (f. p. m.)
Annealed tool steel	Lathe	50 to 70	25 to 35
	Drill press	50 to 60	20 to 30
	Miller	50 to 60	20 to 30
Cold finished machine steel	Lathe	100 to 150	50 to 70
	Drill press	100 to 120	50 to 70
	Miller	100 to 125	50 to 70
Cast iron (C. I.)	Lathe	75 to 175	40 to 80
	Drill Press	100 to 170	40 to 80
	Miller	100 to 150	60 to 80
Brass and bronze	Lathe	150 to 300	70 to 150
	Drill press	200 to 300	100 to 150
	Miller	150 to 250	80 to 125
Aluminum	Lathe	200 to 300	100 to 150
	Drill Press	200 to 300	100 to 150
	Miller	200 to 350	100 to 175

CUTTING SPEED DATA

Directions: Solve each of the problems below using chart where necessary.

Number	Cutting Speed C	RPM R	Diameter d	Material	Tool Steel Used	Machine
1.	Chart		3.625"	Cast Iron	High-Speed	Lathe
2.		110	.875"	Cold finish	High-Speed	Lathe
3.	Chart	300		Aluminum	High-Speed	Mill
4.	Chart		$2\frac{1}{4}$"	Brass	Carbon	Drill
5.		18	$3\frac{1}{2}$"	Cast Iron	High-Speed	Drill
6.	Chart		.625"	Tool Steel	High-Speed	Drill
7.		66	1.875"	Cast Iron	Carbon	Lathe
8.	200	1920		Aluminum	High-Speed	Drill
9.	120		3.375	Cast Iron	High-Speed	Lathe
10.	Chart		6"	Bronze	Carbon	Mill
11.	Chart	3600		Aluminum	Carbon	Drill
12.		75	2.125	Brass	High-Speed	Lathe
13.	Chart		6.5"	Cast Iron	High-Speed	Lathe
14.	Chart		15"	Cold finish	Carbon	Lathe
15.		476	$\frac{1}{2}$"	Cold finish	Carbon	Drill
16.		350	.75"	Bronze	High-Speed	Drill
17.	Chart	275		Aluminum	High-Speed	Mill
18.	Chart	24		Cast Iron	Carbon	Lathe
19.	Chart	320		Tool Steel	High-Speed	Lathe
20.	60	6000		Cold finish	Carbon	Drill

I. Activity: Cutting Speed Inspector

II. Objective: The student should be able to:

Decide whether or not a machine is being operated at the correct cutting speed

III. Materials:

A. Work sheet entitled, "Cutting Speed Inspector"

B. Chart entitled, "Table of Cutting Speeds for Various Machines and Materials"

IV. Suggested Procedure:

A. Hand out the work sheet entitled, "Cutting Speed Inspector."

1. Each student is to decide whether or not the cutting speed is too fast, too slow, or correct.

2. If the cutting speed is too slow, or too fast, the student is to indicate, in the last columns, the correct speed of the machine.

B. Have students get out the Table of Cutting Speeds.

C. Write the short formulas for cutting speed on the board and review the use of each.

D. Work the first problem on the work sheet.

E. Have students complete the work sheet.

CUTTING SPEED INSPECTOR

Directions: You are a machine shop inspector. It is your responsibility to check to see that all machines are operating at the correct speed. First, use the formula to determine the cutting speed given the rpm's of the motor and the diameter of the tool. Second, use your table of cutting speeds to rate the machine. Third, if cutting speed is incorrect, compute the correct rpm's necessary to have the correct cutting speed.

Number	Machine	Tool Steel Used	Material	RPM R	Diameter d	Cutting Speed $C = \frac{dR}{4}$	Cutting Speed			Correct $R = \frac{4C}{d}$
							Too Fast	Too Slow	OK	
1	Lathe	High-Speed	Tool Steel	4800	$\frac{1''}{2}$					
2	Mill	High-Speed	Cold finish	425	1"					
3	Drill	High-Speed	Cast Iron	85	5"					
4	Lathe	Carbon	Brass	200	2"					
5	Mill	Carbon	Bronze	1000	.675"					
6	Drill	Carbon	Aluminum	2000	4"					
7	Lathe	High-Speed	Aluminum	1600	1.250"					
8	Mill	Carbon	Tool Steel	75	$\frac{1''}{8}$					
9	Drill	Carbon	Cold finish	150	.875"					
10	Lathe	High-Speed	Cast Iron	15	2"					
11	Mill	Carbon	Brass	10	6"					
12	Drill	High-Speed	Bronze	300	.750"					
13	Lathe	Carbon	Cold finish	40	3"					

I. Activity: Round Holes for Square Pegs

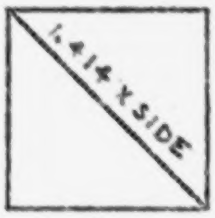
II. Objectives: The student should be able to:

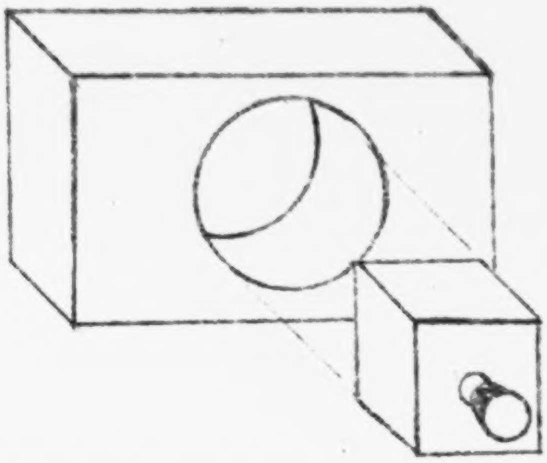
A. State that the diagonal of the square must be smaller than the diameter of the hole in this situation.

B. Apply the given constant (1.414) to determine by multiplication the diagonal length of a square.

III. Background Information:

Many plug gages (inspecting devices) are square even though they are sometimes used to check round holes. The crucial factor in the fit is the diagonal measure of the square as compared to the diameter of the hole.





The concept of a constant will be used here rather than a geometric determination of the diagonal. The notion of a constant is important mathematically, and the use of a constant without knowledge of derivation is realistic for industry.

In order to get a good fit, the factor .005 has been added to the diagonal to determine the desired diameter. To produce a hole a drill must be selected with a diameter equal to or just larger than the desired diameter. Assume that drills are available in 64th intervals up through 2 inches. The decimal equivalent chart can then be used to compare desired diameter and drill size required.

Materials:

A. A large plug gage model can be manufactured easily in the school wood shop. The diagonal should be marked and the factor 1.414 should be placed on it.

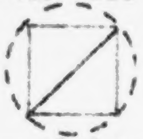
B. An actual size model can easily be made in metal shop.

C. Work sheet entitled, "Round Holes for Square Pegs."

Suggested Procedure:

A. Show the student the plug gage and the block with appropriate size hole (actual scale model). Show how the gage is used to check hole size and point out the good fit. Then tell the students the length of the side of the square (gage plug).

B. Now show the large wooden model. The diagonal should be marked off. Students should recognize that the diagonal length must closely match the diameter of the hole for a good fit. Ask--How do we figure the diameter? If measurement is suggested require an answer to a thousandth of an inch. Since we have used no instruments of this capability yet, we must compute by necessity. Point out also that on drawings and in other situations measurement is not always possible.



C. State that mathematicians have determined that the diagonal is about 1.414 x side for any square. Mention that many skilled tradesmen have memorized and used this factor for years.

D. Pose the problem: What is the smallest hole that a square gage plug, 3/4" (.750) on a side, will fit into? Consider the solution:

.750 x 1.414 = approximate diagonal length.

Point out:

1. that 1.414 is approximate and that the answer should be rounded to the nearest thousandth

2. that we are multiplying by about $1\frac{1}{2}$, so estimate the answer to use as a check later.

E. Go through the multiplication at the board with the class. Check the answer against the estimate. Add .005 to the diagonal to get the diameter for a good fit.

F. The teacher may check at this time with a micrometer or vernier caliper on the actual size metal model.

G. Review the procedure.

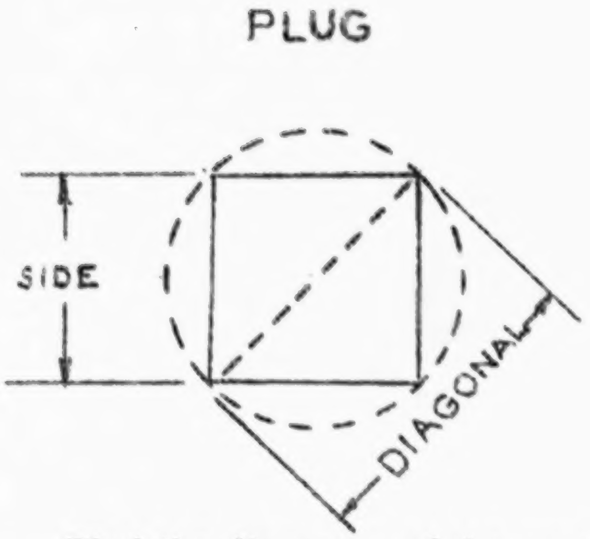
H. Have the class determine the diameter of the smallest hole of a $\frac{1}{2}$" square plug would fit into. Remind them to add .005 to the diagonal to find desired diameter.

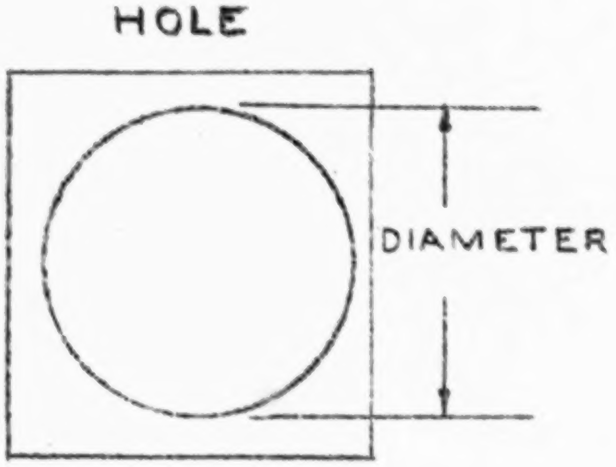
I. Check the work in class at the board. Discuss with the class the method of selecting a drill. Make the assumption that drills are available in 64th intervals up to 2 inches. Using a decimal equivalent table have the class suggest which fractional size drill would best suit the desired diameter. Explain that they should mentally round the table values to three places before comparing them to desired diameter. Mention that the drill size can not be smaller than desired diameter.

J. As an optional exercise a square piece of $\frac{1}{2}$" stock might be inserted into a hole drilled by the selected drill size. This may be prepared beforehand or mentioned at this time and completed for the next class period.

K. Assign the work sheet entitled, "Round Holes for Square Pegs."

ROUND HOLES FOR SQUARE PEGS





1. Find the diameter of the smallest hole in which each square plug will fit. Fill out columns A and B.
   a. diagonal = 1.414 x side
   b. all answers are rounded to thousandths
   c. desired diameter = diagonal + .005 (allowance for fit)

		A	B	C	D
Gage Plug	Length of Side	Diagonal of Square	Desired Diameter of Hole	Table Decimal to 3 Places	Fractional Drill Size
#1	.250"				
#2	.125"				
#3	.375"				
#4	.625"				
#5	.875"				

2. Drills are made for each 64th of an inch. Using the decimal equivalent table select the fractional size drill needed for the desired diameter hole. Round table values to thousandths. Drill holes must be the same size or larger than desired diameter.

I. Activity: Square Pegs for Round Holes

II. Objectives: The student should be able to:

A. State that the diameter of a hole must just exceed the diagonal length of a square gage plug for the plug to fit well in the hole

B. Apply the given constant (.707) to determine by multiplication the side length of a square which will best fit into a given round hole

III. Background Information:

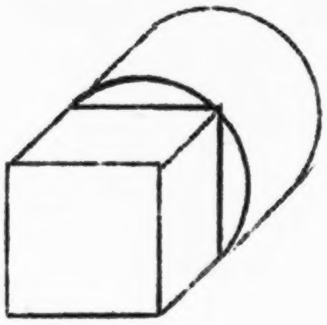
The best introduction for this lesson is to check the work sheet "Round Holes for Square Pegs." Once again students need basic multiplication skills and should be able to round off numbers. This lesson is the reverse procedure--start with a hole diameter and work back to the side length of the square plug to be inserted. The allowance for fit is still .005, but we will now subtract it from given diameter when fitting the square into the hole.

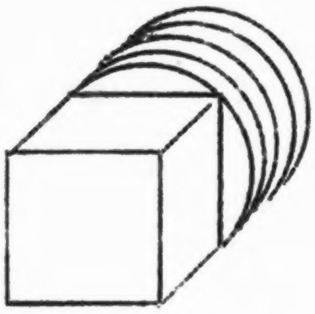
IV. Materials:

A. Piece of round stock made square at one end

B. Plug pipe-fitting

C. Chalkboard compass

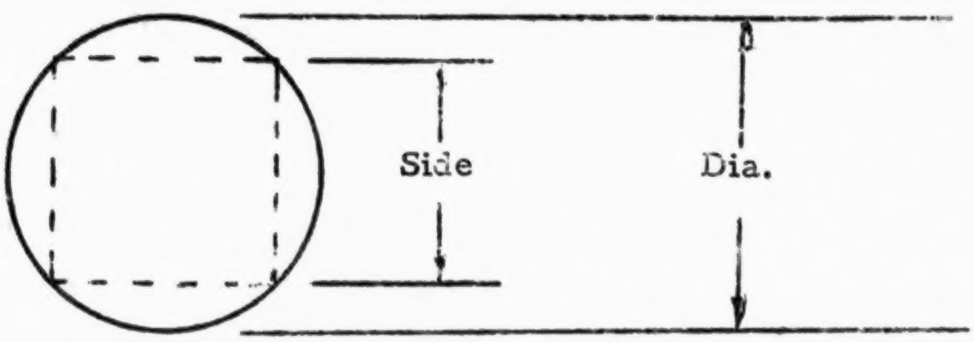




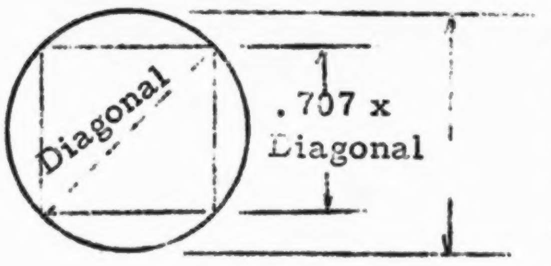
D. Student work sheet entitled, "Square Pegs for Round Holes"

V. Suggested Procedure:

A. Show the round end of the round stock. Suggest the problem of wanting to machine the biggest possible square from the end of this round stock. Show the class the other end where this has already been done. Put a drawing on the board.



B. Ask--If the diameter is 1", what would the diagonal be? (No allowance for fit is needed here since the square doesn't actually fit inside the circle, but merely matches it. This should be pointed out.) Then, the diagonal is 1" also. Previously we multiplied side length by 1.414 to get diameter. Ask--What could we do to find side length? Someone may suggest divide by 1.414. Agree, but mention there is a simpler way (i.e. it is easier to multiply than divide). Put the second drawing on the board.



Mention that multiplication by a number smaller than one produces a smaller number and show this with a progression of multiplication; 3 x 1, 2 x 1, 1 x 1, .5 x 1, etc.

C. State that mathematicians have determined that side length of a square is about .707 x diagonal. Compute the side of a square machined from 1" round stock. Round to thousandths.

D. Point out that this problem occurs in industry when making plug pipe fittings (display one). Ask--What will the side of the square be if the round stock is $1\frac{1}{4}$" diameter? 1.250" x .707. Check at the board.

E. Pose the problem--Suppose we want to machine a square plug that will just fit in a hole $1\frac{1}{4}$" in diameter. Now we need to make an allowance of .005 for fit. How long should the diagonal be? (1.250-.005) Now that we have the diagonal, use the .707 factor to determine the length of the side.

$$.707 \times 1.245 = \text{length of side}$$

F. Distribute and discuss the work sheet "Square Pegs for Round Holes." Have students complete the work sheet.

SQUARE PEGS FOR ROUND HOLES

Directions:

1. Subtract diagonal allowance from the hole diameter to determine diagonal length. Complete Column A for all 10 examples.
2. Multiply diagonal length times .707 to find side length. Round to thousandths and record in Column B.

		A		B
Hole Diameter	Diagonal Allowance	Diagonal Length	Factor for Side Length	Side Length
2.000"	.005		.707	
2.750"	.005		.707	
4.000"	.005		.707	
1.500"	.005		.707	
10.000"	.005		.707	
.500"	.000		.707	
1.125"	.000		.707	
3.000"	.000		.707	
.875"	.000		.707	
5/8"	.000		.707	

I. Activity: Making a Hex Nut

II. Objectives: The student should be able to:

A. State that hexagons can be constructed(mechanically) from circles by cutting off six arcs.

B. Apply a constant to compute by multiplication of decimals the distance across the flats (parallel sides) for a hexagon machined from a given size round stock.

C. Apply a constant to compute the diameter of circle needed to machine a specific size hexagon.

III. Background Information:

The "distance across the flats" must be defined and can easily be done from a labeled drawing. The student must be able to multiply and round answers to thousandths. A check of the worksheet "Square Pegs for Round Holes" will serve as an introduction.

IV. Materials:

A. One piece of hexagonal stock.

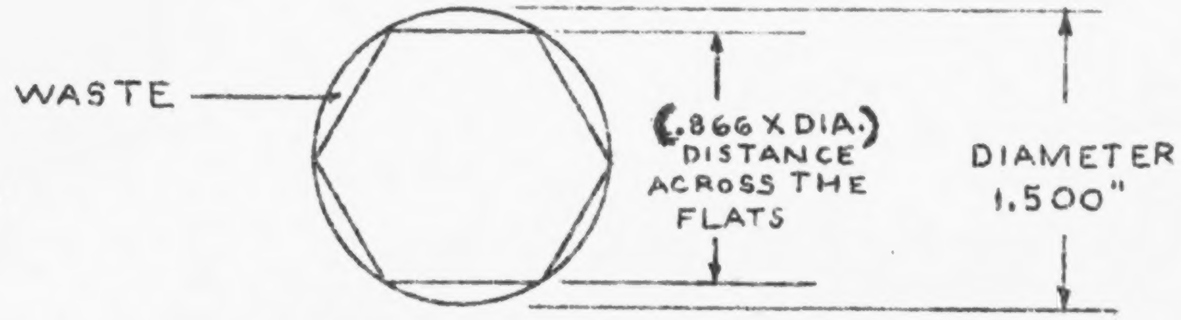
B. One piece of round stock with a hexagon on one end.

C. Chalkboard compass.

D. Hex nut (s).

V. Suggested Procedure:

A. Define "distance across the flats" from a drawing on the board.



B. Display hexagonal stock and a hex nut. To make a hex nut, hexagonal stock or a hexagon in any situation we usually start with a circle. To set the machine to cut (mill) this stock from circular to hexagonal the distance across the flats is needed. The machine is then set according to this distance and the excess will be trimmed.

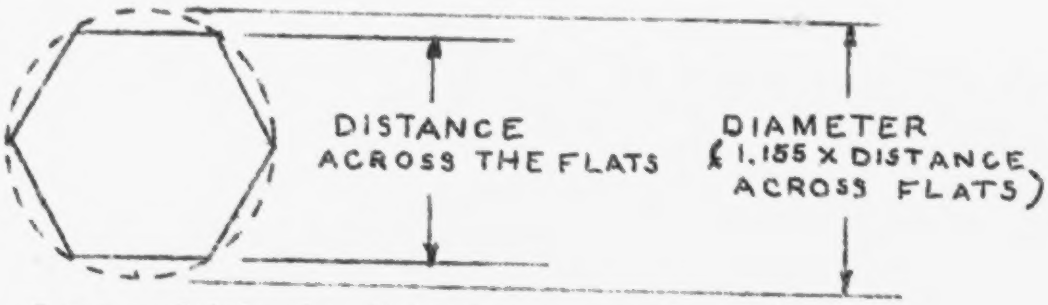
C. If we start with round stock then the diameter is known. Mathematicians have determined that the distance across the flats is .866 times the diameter.

D. For example, if we start with 1.500" round stock, we figure: .866 x 1.500 = distance across the flats. (Check work at the board.)

E. Have students determine the distance across the flats if we start with 1.000" diameter round stock.

F. Measure and compare these distances on a hex nut as an illustration. Check these measurements against a computed value.

G. Have the class consider a problem: A hexagon is required with a one inch distance across the flats. The diameter of round stock is required before we can start milling. Once again, mathematicians have determined a constant (1.155) for this case.


DISTANCE ACROSS THE FLATS
DIAMETER (1.155 x DISTANCE ACROSS FLATS)

H. Have the class multiply the distance across the flats by 1.155 to find the diameter. Point out that using the smallest possible round stock will minimize waste of time, money, and material.

I. Pose the problem: Suppose that a hexagon is needed which has a distance across the flats of .875. What diameter round stock is required? .875 x 1.155 (Point out that we expect a diameter larger than .875, approximately 1.000. Multiplying, the result is 1.011 to the nearest thousandth.)

J. Inform the class that round stock can be ordered in multiples of 16ths. Since 1.000" round stock is too small, we would go to 1 1/16" stock (1.0625" from the table).

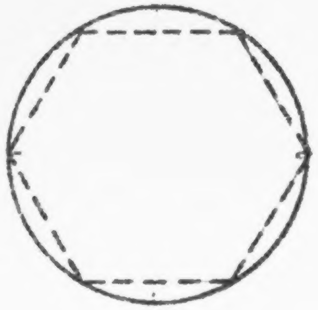
K. Ask the class to find the diameter round stock we must order if the distance across the flats must be 1.000".
1.000" x 1.155 = 1.155" 1 3/16 round stock required (1.188")

L. Have the students complete the worksheet entitled, "Making a Hex Nut."

MAKING A HEX NUT

Directions:

1. Given the distance across the flats, find the diameter of the round stock required to mill the hexagon. Use the 1.155 factor provided.



2. Given the diameter of the round stock, find the distance across the flats for the largest hexagon that can be milled. Use the .866 factor provided.

Distance Across the Flats	Required Factor	Diameter of Round Stock (only in intervals of 1/16", use the table)
.939	1.155	
.750	1.155	
1.250	1.155	
.250	1.155	
.625	1.155	
	.866	.500"
	.866	.875"
	.866	1.500"
	.866	1.250"
	.866	.750"

I. Activity: Milling an Equilateral Triangle

II. Objectives: The student should be able to:

   A. State the relationship between an equilateral triangle and a hexagon

   B. Apply a constant to compute the side length of an equilateral triangle

III. Background Information:

The equilateral triangle is an unusual milling problem. Some of its uses include bolt heads which, of course, require special wrenches. These are used for public utilities to prevent tampering by unauthorized personnel.

The geometrical insights of inscribing regular polygons can be very useful for sheet metal layouts. Emphasize the similarity between the hexagon and equilateral triangle.

IV. Materials:

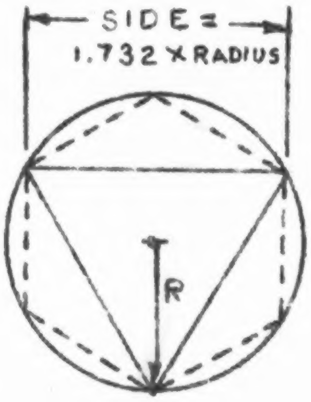
   A. Piece of round stock with hexagon milled on one end and an equilateral triangle milled from part of the hexagon. See the machine shop teacher

   B. Chalkboard compass and classroom quantity of compasses

   C. Steel scales

V. Procedure:

   A. Have the drawing below on the board before the beginning of class.



B. Since the hexagon should be a familiar figure to the class at this time, point out that the equilateral triangle has one side for every two of the hexagon. The case of construction from a hexagon is apparent. Ask the class why bolts and nuts aren't made into triangles. Answers should vary from too much waste to impracticability for wrench fits. Mention that the 60° angle is very important in many trades and that all three angles are 60°. Point out that a situation similar to this might occur, but should present no problem since the equilateral triangle is so similar to the hexagon.

C. Tell the class that, once again, mathematicians have determined a factor (1.732) which is multiplied by the radius of the circle to find the length of a side. If we started with 1.000" round stock, the problem would be:
radius = .500" 1.732 x .500 = side length
Have the class work the example.

D. Starting with 1.500" round stock, what would the length of the side be for an equilateral triangle. (Check work at the board.)

E. Pass out student compasses. Demonstrate how to inscribe a hexagon in a circle at the chalkboard.

F. Have students construct circles of various radius and inscribe hexagons. Demonstrate and then have the class connect every other vertex to form an equilateral triangle.

G. Have the students start another construction. Set the compass at a 1" radius and draw a circle. Construct a hexagon in the circle, then an equilateral triangle. Point out that the hexagon is not inscribed perfectly.

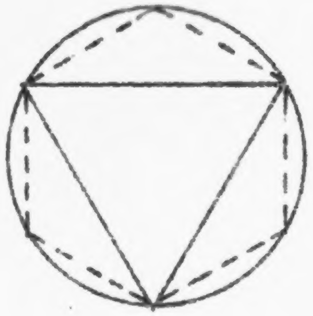
H. Refer to the factor (1.732) and have students compute the side length for the equilateral triangle. 1" x 1.732 = 1.732"

I. Have students measure the side length with steel rules and compare the decimal equivalent of the measurement (using a table) to the computed value (1.732"). Remind the class of the imperfect inscription and its effect on the measurement.

J. Have the students complete the work sheet entitled, "Milling an Equilateral Triangle."

MILLING AN EQUILATERAL TRIANGLE

Directions: Find the length of the side of an equilateral triangle milled from the round stock given. Use the factor 1.732 and the decimal equivalent table.



Diameter of Round Stock	Radius (Thousandths)	Factor	Side Length (Thousandths)
4"		1.732	
3"		1.732	
2"		1.732	
$1\frac{1}{2}$" (1.500")		1.732	
$1\frac{1}{4}$" (1.250")		1.732	
$\frac{7}{8}$" (.875")		1.732	
$\frac{3}{4}$" (.750")		1.732	
$\frac{1}{2}$" (.500")		1.732	
$\frac{3}{8}$" (.375")		1.732	
$\frac{1}{8}$" (.125")		1.732	

I. Activity: Can It!

II. Objectives: The student should be able to:

A. Measure length on a curve with string

B. Compute length on a curve using the formula $C = \pi D$

C. Use measurements and computations to solve applied math problems

III. Background Information:

Cylinders are often made in industry by rolling a sheet and making a seam to join the edges. If a certain diameter is required the problem is: How wide should the sheet be? Realistically an allowance for the seam should be added. Direct and computed measure should be used concurrently and as cross-checking devices.

IV. Materials:

A. Teacher--cloth tape, pre-assembled tin can, short lengths of string, assembled tin can

B. Students--3' length of string (brought to class), steel scale or ruler, work sheet entitled, "Can It!"

V. Suggested Procedure:

A. Describe the process used in industry to make a cylinder. Then display the pre-assembled can and show how it is rolled into a cylinder. Point out the space allowed for the seam. Ask the class to name the type figure used to make up the sides, not including the top. Then show the assembled can.

B. Have the class assemble some cylinders with paper. Have everyone roll a piece of paper into a 2" diameter cylinder checking diameter with steel scales. Marking the seam with a pencil, unroll the paper and measure the width of the rectangle. Repeat this process for a 3" diameter circle and a 2.5" diameter circle. Draw a table on the board as follows and complete:

Diameter	Width
2"	
2.5"	
3"	

C. Have students compare diameter and circumference in each case, then project an answer for a 10" diameter. Students should recognize that circumference is a little more than three times the diameter and possibly some will remember that circumference is π times diameter.

D. Write circumference above width and state the formula $C = \pi D$ for all students to copy. Tell students that materials are often too heavy to roll, such as steel for a boiler, and we have to decide on width (circumference) so the right size steel sheet is made.

E. Work an example for a can 4" in diameter. Pass out the work sheet entitled, "Can It!" and have students follow each step.

CAN IT!

Directions:

1. Compute circumference to hundredths of an inch. $C = \pi D$
2. Add the seam allowance for desired length.
3. Using the tolerance find the longest and shortest acceptable lengths by adding and subtracting respectively.

Diameter	Computed Circumference	Seam Allowance	Desired Length	Tolerance	Inspector's Guide	
					Longest Length	Shortest Length
4"	12.56"	.50"	13.06"	± .25"	13.31"	12.81"
2'		1.00"		±.25"		
4'		2.00"		±.50"		
6"		.50"		±.25"		
8"		$\frac{1}{2}$"		± $\frac{1}{4}$"		
3"		$\frac{1}{4}$"		± $\frac{1}{16}$"		
9"		$\frac{1}{2}$"		± $\frac{1}{16}$"		
1'		$\frac{3}{4}$"		± $\frac{1}{8}$"		

I. Activity: Bolts with Square Shanks and Design Problems

II. Objectives: The student should be able to:

- A. Inscribe a circle in a square
- B. Inscribe a circle in an equilateral triangle
- C. Find the diameter of the inscribed circle of an equilateral triangle

III. Background Information:

Problems involving squares inscribed in circles are very simple and involve little computation. The purpose of this type problem is to give the student an opportunity to do some informal geometric constructions and see first-hand the relationships involved. Informal work on basic geometric constructions would probably hold student interest after these lessons.

Inscription of circles in equilateral triangles are not common since much waste is involved. Once again practice with geometric constructions is important and students should enjoy it. The 60° angle will be important in many instances and this fact should be mentioned to students. Point out that slight errors will be made in drawings due to pencil line widths, poor instruments, etc.

IV. Materials:

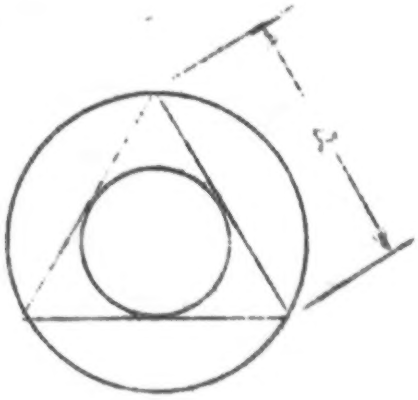
- A. Compasses
- B. Steel scales
- C. Protractors
- D. Work sheet entitled, "Three Cornered Problems"

V. Suggested Procedure:

A. Display a bolt with a square shank. (One can be found easily or purchased for a few cents.) The body of the bolt is made from the same stock, but part is circular, part square. Show students how the diameter matches the square. Ask: "To put a circle in a square, what do we need to know? (diameter = side of square)

B. Have students draw a square 2" x 2" and a rectangle 3" x 5" on a piece of paper. Pass compasses out and have them decide how to inscribe the largest possible circle in each. Ask students how to locate the center of the square and rectangle. (intersection of diagonals) Have students inscribe the circles and make observations on this situation (i. e. amount of waste, best methods, etc.).

C. Have students study the design (from the board).



Pose the following problem:

A company desires to produce a stamp to label packages with the emblem shown. The triangle is equilateral (review briefly) and the circle is inscribed (the largest circle that will fit inside). How can the emblem be designed?

D. State that: On large boxes the side of the triangle (a) must be 10" in length. On small boxes the side (a) must be 6". On small packages the side (a) must be 2". Ask, "What would the diameter of the inscribed circle be?" Pass out compasses and steel scales and have students attempt to duplicate the drawing with the triangle side equal to 6". Show students how to draw equilateral triangles and to locate the center of the inscribed circle by finding the midpoint of each side and connecting each to the vertex opposite that side. Point out that this is the center of the equilateral triangle (that the triangle could be balanced on a pin here) and that it serves as the common center for the inscribed and circumscribed circles. Have students decide on each radius and draw both. Then show students the entire operation on the board also.

E. Tell students to measure the diameter of the inscribed circle. Then state that mathematicians have determined a constant, .577, which is multiplied by the side of the triangle (a) to find the diameter of the inscribed circle. Multiply (.577 x 6") to check the measurement and use the decimal equivalent table.

F. Have students measure the diameter of the circumscribed circle. State that mathematicians have determined that this diameter is equal to 1.155 x side of triangle (a). Have students multiply to check their measurement.

G. Have students repeat the entire process with an equilateral triangle of side 5.

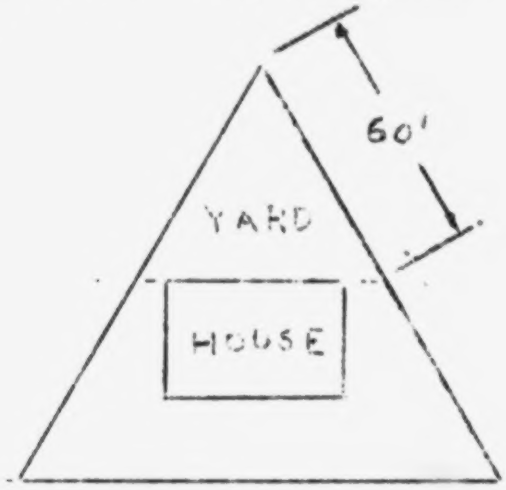
H. Assign the problems on the work sheet entitled, "Three Cornered Problems."

THREE CORNERED PROBLEMS

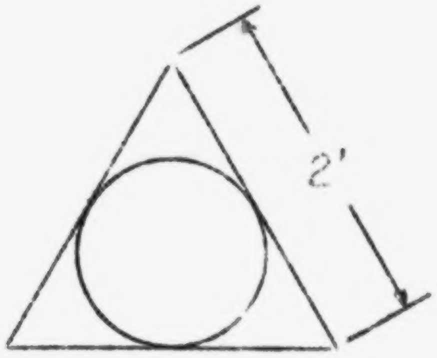
Directions: A. All the triangles mentioned in the following problems are equilateral triangles and answers depend upon the diameters of inscribed or circumscribed circles.

B. Select the formula needed: inscribed circle diameter, D = .577 x side of triangle; circumscribed circle diameter, D = 1.155 x side of triangle.

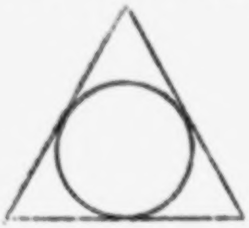
1. Mr. Apothem's back yard is an equilateral triangle and he wishes to tie his dog back there. How long a chain should he buy so that the dog cannot go into the neighbor's yard, but has as much space as possible in the yard. The dog will be staked in the center of the back yard.



2. Mr. Plunger, a plumber, wants to put the largest possible pipe through an equilateral triangle opening formed by a wall and two pipes



3. Mr. Whipcracker is the boss in a design shop which will produce the emblem shown below. If he has to make two different size equilateral triangles, 12" and 2", what would the diameter of the circle be in each case?



4. From a previous swimming pool Mr. C. Nettle has a hole in his back yard in the shape of an equilateral triangle. He wants to build a circular pool. To save money what is the smallest diameter pool he can build to completely cover the hole if the side of the triangle is 20 feet?

5. When Mr. Apothem's dog died he decided to put a circular pool in his triangular back yard. If he must stay 10 feet from both neighbors' property and his house, what would the diameter of the biggest possible pool be?

I. Activity: Triangle Measure

II. Objectives: The student should be able to:

A. Name the sides of a right triangle in terms of either acute angle as adjacent, opposite or hypotenuse

B. Identify similar triangles and construct ratios for proportional sides

C. Compute sine, cosine, and tangent values by measuring triangle sides, comparing their lengths and dividing

III. Background Information:

It would be helpful to cover certain topics before this lesson. From algebra discuss ratios and use of formulas. From geometry discuss angles, types of triangles, sum of the angles of triangles, right triangles, perpendicular lines, complementary and supplementary angles, and similar triangles.

This lesson should be modified according to the background of the class. The work sheets should be saved for review purposes.

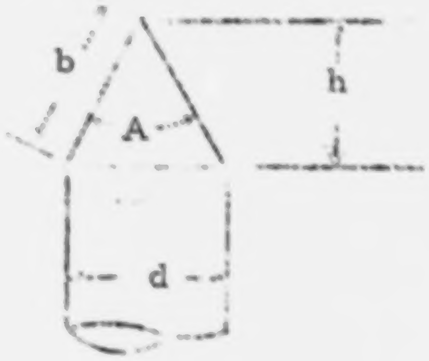
IV. Materials:

A. A 3 page work sheet entitled, "Triangle Measure"

B. Steel scales

V. Suggested Procedure:

A. Pose this problem:
A steel bar, as shown, has a diameter d = 1" and is tapered to a point. If the perpendicular distance $h = 1\frac{1}{16}$"



1. find the angle A at the tip of the taper

2. find the length b

B. Analyze the solution for the class to point out the need for and use of trigonometry in industry. Tell them that we are concerned with a triangle and that trigonometry translates into triangle measure. Point out that there is no other method of solution available. State that there are relationships between the angles of a triangle and ratios of side lengths and that each angle possesses certain factors which are determined by trigonometry.

C. Now that need is shown, tell the class that they are prepared to learn some trigonometry. Assure them that there will be no difficulty. Pass out the work sheets (pages 1 and 2) entitled, "Triangle Measure." Tell the class that trig is based on ratios or comparisons of the lengths of the sides of right triangles.

D. Quickly review the right triangle terminology, perpendicular lines, complementary angles, specifying triangles by letters and the angle sum of a triangle.

E. Pass out the steel scales and have students measure and complete page 2.

F. Pass out page 3 and have students use page 2 to complete column A in set I, then divide to complete column B in set I.

G. When set I is completed, ask:

1. Why is #1 different than #2? #3? (Students should say that the angles differ in size.)
2. Why is #4 the same as #1? Why is #5 the same as #4 and #1? (Students should say the angle is the same.)
3. What other ratio(s) would give us the same result as #2? #3?

H. Have students complete the statement: The ratio depends upon the size of the angle. Then tell students that in terms of the angles we have general names for the different sides of the right triangle. Draw a right triangle on the board, mark an angle, and have students specify the "opposite side, adjacent side, and hypotenuse." Ask, In set I what kind of ratios do we have? $\left(\frac{\text{opposite}}{\text{hypotenuse}}\right)$

State that this ratio has a name, "sine," abbreviated as sin. It is just a name given to the ratio $\frac{\text{opposite}}{\text{hypotenuse}}$.

I. Discuss similar triangles with the class. Ask why triangles ABC and ADE are called similar.

J. Have the class complete set II. When completed ask:

1. Why is #1 different than #2? (different angle size)
2. What do you notice about #3? (same as #2)
3. What other ratios of this type would be the same?
4. In terms of the angle what would this ratio be in words? ($\frac{\text{adjacent side}}{\text{hypotenuse}}$)

   State that this ratio is called "cosine," abbreviated cos.

K. Repeat this process with set III. Ask:

1. Why are #1 and #2 different?
2. Why is #3 the same as #1?
3. What is the ratio in words? ($\frac{\text{opposite}}{\text{adjacent}}$)

   State that this ratio is called tangent.

L. Mention that there are three other ratios, but they are just the reciprocals of these. (Names and examples may be mentioned, but do not confuse the student.) Inform the students that the sine, cosine, and tangent can be used to find any answer needed.

VI. Suggested Evaluation:

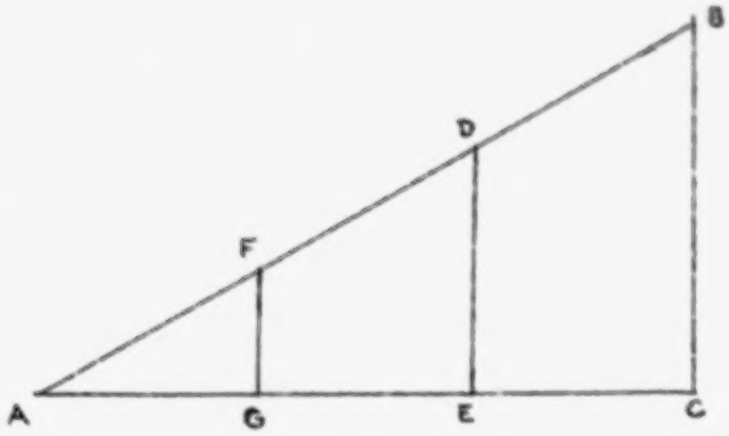
A. Have students write or state the ratios.

B. Have students find ratios for some similar triangles and determine side lengths.

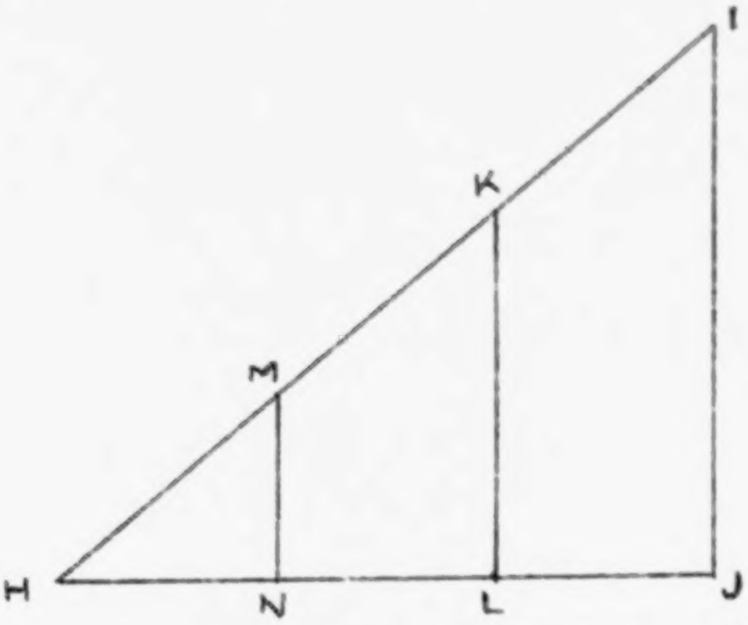
TRIANGLE MEASURE

All triangles are right triangles.

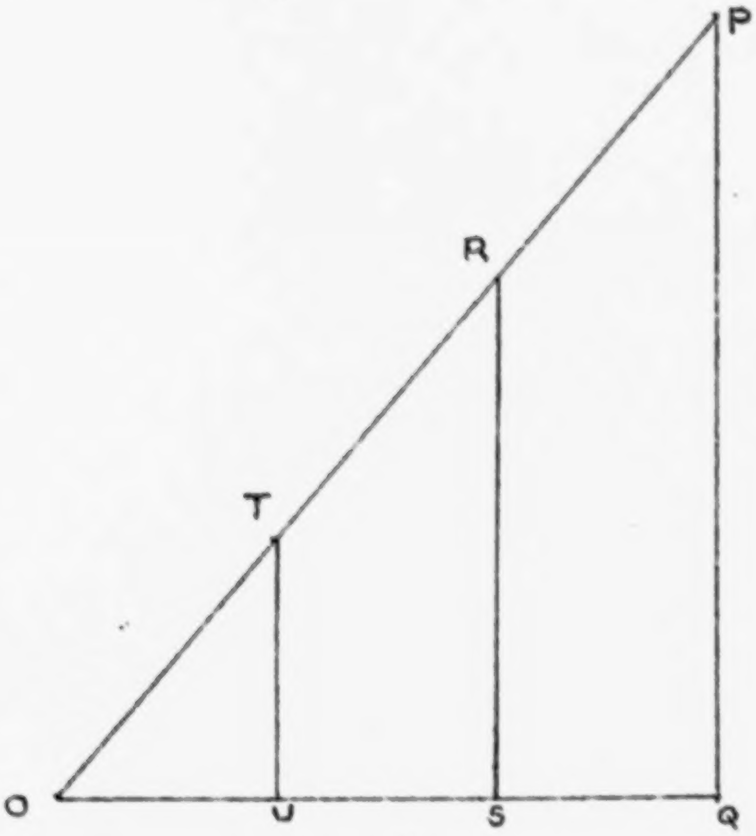
I



II



III



TRIANGLE MEASURE

Directions:

1. Measure the indicated line to the nearest 16th inch and record the measurement in column A.
2. Using a table, find the decimal equivalent in thousandths.
3. Several examples have been completed.

	A	B
Line	Measurement	Decimal Equivalent of Measurement
AC	$1\frac{22}{32}''$ $(1\frac{11}{16}'')$	1.688
BC	$3\frac{14}{32}''$ $(3\frac{7}{16}'')$	3.438
AB		
AE		
DE		
AD		
AG		
FG		
AF		
HJ		
IJ		
HI		
HL		
KL		
HK		
HN		
MN		
HM		
OQ		
PQ		
OP		

TRIANGLE MEASURE

1. Take the corresponding measurements from column B on page 2
2. Divide to find a quotient in thousandths.
3. An example has been done for you.

Ratio	A Measurements	B Quotient
Set I 1. $\frac{BC}{AB}$	$\frac{1.688}{3.438}$	.491
2. $\frac{IJ}{HI}$		
3. $\frac{PQ}{OP}$		
4. $\frac{DE}{AD}$		
5. $\frac{FG}{AF}$		
Set II 1. $\frac{AC}{AB}$		
2. $\frac{HJ}{HI}$		
3. $\frac{HL}{HK}$		
Set III 1. $\frac{BC}{AC}$		
2. $\frac{PQ}{OQ}$		
3. $\frac{DE}{AE}$		

I. Activity: A Homemade Trig Table

II. Objectives: The student should be able to:

A. Draw a circle of radius 10 blocks and mark off certain angles in the first quadrant.

B. Draw perpendiculars to the x-axis to make right triangles

C. State the definitions of sine, cosine, and tangent ratios

D. Identify adjacent, opposite, and hypotenuse for each triangle

E. Select the sides required for a certain ratio and measure them

III. Background Information:

Stress the three trig ratios repeatedly. Students should have enough class time to do about half the trig table. Measurement of sides rather than counting and estimating blocks will produce more realistic ratios. The computations should be finished for homework and compared to the table when it is introduced in the next lesson. Have students save work sheets for review purposes.

IV. Materials:

A. Steel scales

B. Compasses

C. Protractors

D. Two-page work sheet entitled, "Homemade Trig Tables"

E. Chalkboard compass and protractor

F. $\frac{1}{5}$" graph paper

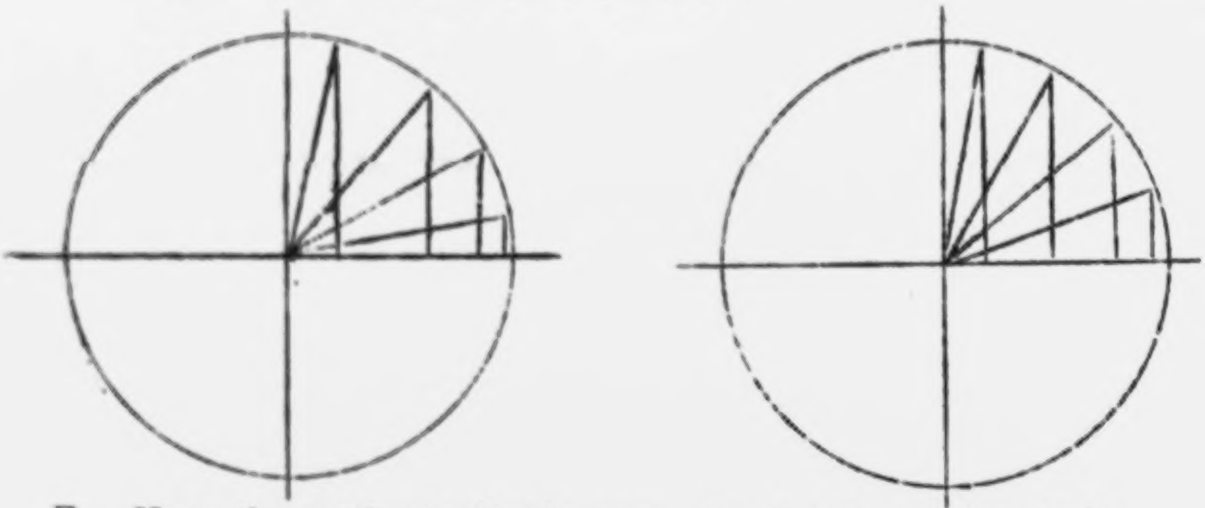
V. Suggested Procedure:

A. Have students state the sine, cosine, and tangent definitions and write them on the board. Then draw a right triangle, mark an acute angle and have students identify each of the sides.

B. Point out that in order to use trigonometry to solve problems it will be necessary to construct some tables.

C. Pass out $\frac{1}{5}$" graph paper and compasses at this time. Draw the graph on the board while students work at their seats so that they may check their work easily.

D. Have the students draw two circles on the paper with a 10 block radius. Under the top circle have them write 10°, 30°, 50°, 70°, 90°. Under the bottom circle have them write 20°, 40°, 60°, 80°.



E. Have the students divide each circle into quadrants by drawing in vertical and horizontal diameters. (Concurrently carry out the instructions on the board.) Pass out protractors at this time.

F. Have students line up protractors and make increment marks for the angles specified below each circle.

G. Pass out steel scales or rulers and tell students to use a straight edge and draw a perpendicular line from the outer endpoint of each radius line down to the 0° line. Ask what type triangles we have drawn. Have them complete triangles for every angle. (Note: If rulers are used, students later will have to mentally determine 32nds between 16th divisions.)

H. Pass out the 2-page work sheet entitled, "Homemade Trig Tables." Refer to the three trig definitions on the board (and the work sheet) and go through the example with the class. The class should measure to check. Show the class how to simplify a complex fraction with the same denominators. Then have the class use a decimal equivalent chart to get a decimal number for each fraction. Finally, have each decimal entered in the table until the table is completed.

VI. Suggested Evaluation:

A. Have students measure the sides of a given triangle and use their tables to determine the angles.

B. Have students state which function is specified by two given sides of a triangle.

C. Have students complete a table matching decimals with fractions of a given angle and/or vice versa.

HOMEMADE TRIG TABLES

Directions:
1. Measure to the nearest 32nd of an inch.
2. Write the measurements as a ratio.
3. Divide to find a decimal in thousandths and round to two places.
4. Several examples have been done for you.

sine of an angle = $\frac{\text{opposite side}}{\text{hypotenuse}}$	cosine of an angle = $\frac{\text{adjacent side}}{\text{hypotenuse}}$	tangent of an angle = $\frac{\text{opposite side}}{\text{adjacent side}}$
sin 10° = $\frac{\frac{11''}{32}}{2''}$ = .17	cos 10° = $\frac{1\frac{15''}{16}}{2''}$ = .97	tan 10° = $\frac{\frac{11}{32}}{\frac{31}{16}}$ = .18
sin 20°	cos 20	tan 20
sin 30°	cos 30	tan 30
sin 40°	cos 40	tan 40
sin 50°	cos 50	tan 50
sin 60°	cos 60	tan 60
sin 70°	cos 70	tan 70
sin 80°	cos 80	tan 80
sin 90°	cos 90	tan 90

HOMEMADE TRIG TABLES

Directions: Enter the decimal computed for each angle in the proper column.

Angle	Sine	Cosine	Tangent
10°			
20°			
30°			
40°			
50°			
60°			
70°			
80°			
90°			

I. Activity: Checking a Taper

II. Objectives: The student should be able to:

A. Find the sine, cosine, and tangent of any angle from 0° 0' to 89° 60' from a table

B. Find the angle corresponding to a decimal number representing a sine, cosine or tangent from a table

C. State sine, cosine, and tangent ratios and compute them from given right triangles

III. Background Information:

Spend as much time as necessary to ensure that students can use the tables effectively. Check work closely before continuing even if the activity should stretch out to several days.

The 60° center punch is a widespread shop project and one can be borrowed easily. Allow class time for any work using the tables unless enough trig booklets are available for all classes.

Stress the problem solving process and insist that student work be neat, organized, and complete for each problem.

If more trig applications are desired, see other references or the shop department. The transit can be developed into a unit and the device itself is an excellent motivator.

IV. Materials:

A. Work sheet entitled, "Using Trig Tables"

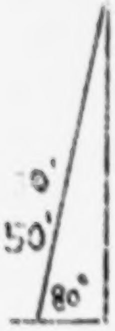
B. Steel scales

C. Sixty degree (60°) center punch

D. Work sheet entitled, "Putting Trig to Work"

V.. Suggested Procedure:

A. Have students take out the work sheet entitled, "Homemade Trig Tables." To show their usefulness pose this problem: A 50' ladder rests at an angle of 80° against a house. How high on the house does the ladder touch?



B. Have students sketch and label the resulting triangle. Ask, in reference to the 80° angle, what side is required? Then ask which trig definition includes these two. Then have students fill in numbers and compute using their computed value for sine 80°. Answers

$$\text{sine } 80° = \frac{\text{opposite side}}{50}$$

should be to the nearest foot. Impress upon students here the importance of trig tables.

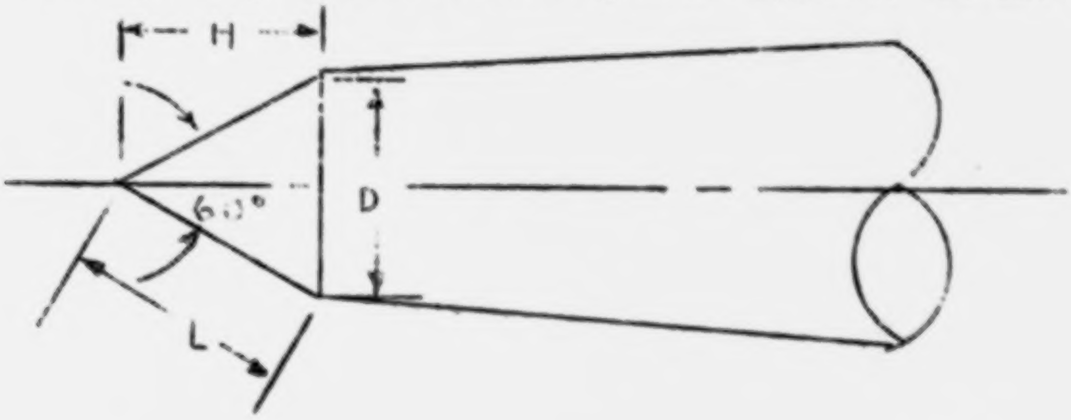
C. Tell students that tables are prepared with 3, 4, 5 or more place decimals according to the precision required for the work involved. Pass out the trig booklets Handy Multipliers and Trigonometry Tables for Engineers and have students compare their table with the table in the booklet.

D. Explain the use of the table for angles from 0°0' to 44°59' and have the class respond after several examples.

E. Repeat the process for angles from 45° to 90°. (To show why sine 30° equals cosine 60° a triangle cut from paper can be used to show that the ratio of sides is the same.)

F. Pass out the work sheet entitled, "Using Trig Tables" and have the class complete them. Individual instruction may be necessary at this time.

G. After checking and answering questions tell students that they can now put their trig to use. The 60° center punch is a common metal shop project in the tenth grade. In making this project a certain taper is required. To check



the taper, l should measure to a specific length. Find l to a thousandth inch if d is one inch.

H. Students should readily see that the right triangle has an angle of 30° when the perpendicular is dropped and that the opposite side is a radius of .500 inches. They may suggest sine or tangent, but in either case the equation must be rearranged for solution. Go through the solution with the class with particular emphasis on analysis and format organization.

I. Give the class the following worksheet as classwork and homework. Be certain that they adhere to the format used in the example. Stress this throughout and grade accordingly.

USING TRIG TABLES

I. Find the decimal value in the table and fill in the blank.

A. sin 13° =

B. cos 13° =

C. tan 13° =

D. sin 30° =

E. cos 30° =

F. tan 30° =

G. sin 45° =

H. cos 45° =

I. tan 45° =

J. sin 60° =

K. cos 60° =

L. tan 60° =

M. sin 57°20' =

N. cos 68°40' =

O. tan 72°15' =

P. sin 90° =

II. Find the angle which has the indicated sine, cosine, or tangent decimal value.

A. sin A = .22495, A = _____

B. sin B = .42262, B = _____

C. cos C = .91354, C = _____

D. cos D = .97815, D = _____

E. tan E = .48773, E = _____

F. tan F = .80020, F = _____

G. sin G = .51004, G = _____

H. cos H = .33298, H = _____

I. tan I = .78881, I = _____

J. sin J = .90814, J = _____

K. sin K = .91354, K = _____

L. cos L = .51004, L = _____

M. cos M = .41337, M = _____

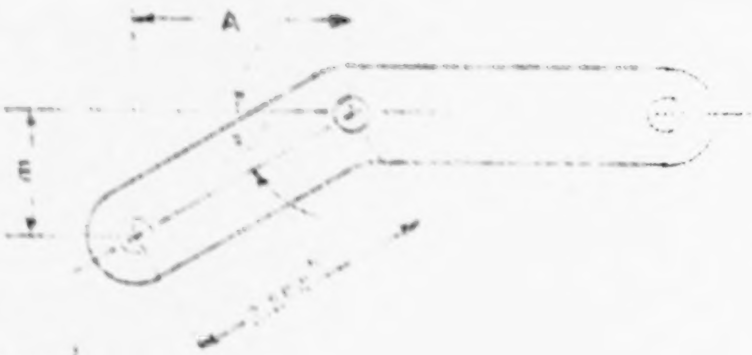
N. tan N = 3.8436, N = _____

O. tan O = 1.0000, O = _____

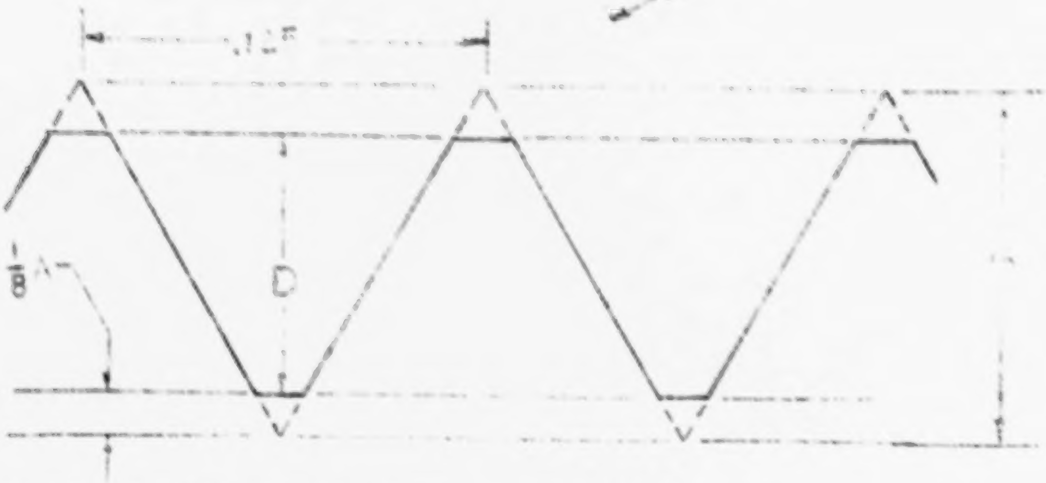
P. tan P = .03492, P = _____

PUTTING TRIG TO WORK

1. Find dimensions A and B to thousandths for the rocker arm. (Hint: Use sine for A, cosine for B.)

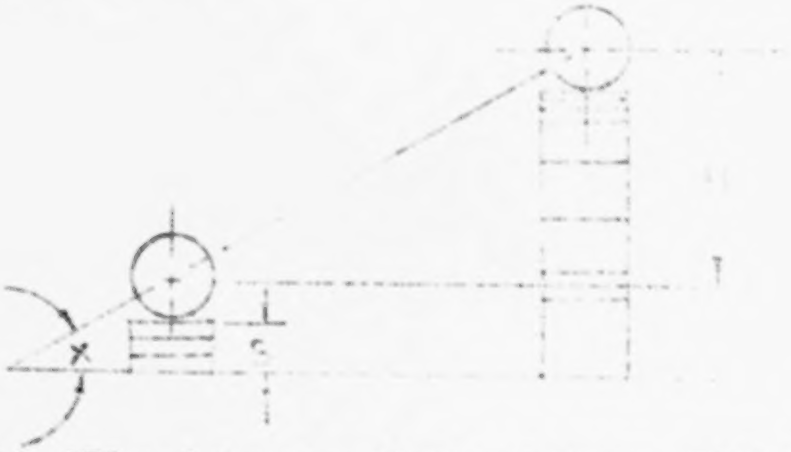


2.



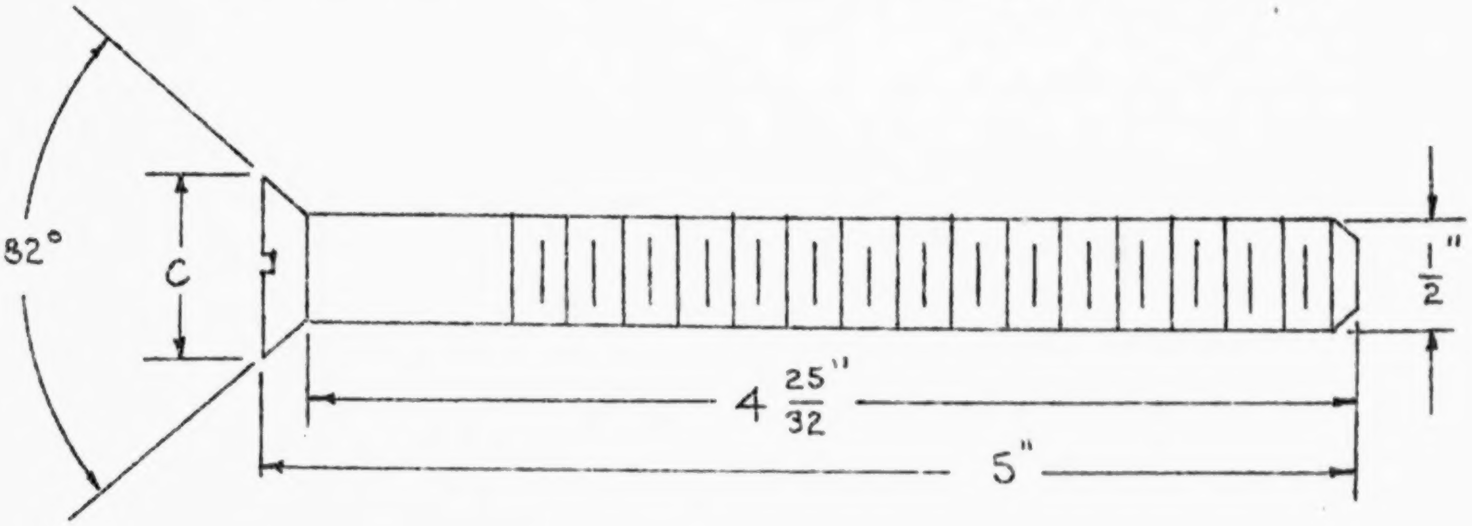
Compute the depth (D) of a National Form (60°) screw thread according to the dimensions given on the drawing. (Hint: Find the height of the triangle (A) and then subtract $\frac{1}{8}$ A from the top and from the bottom.)

3. Study the combination of sine bar and gage blocks used here.



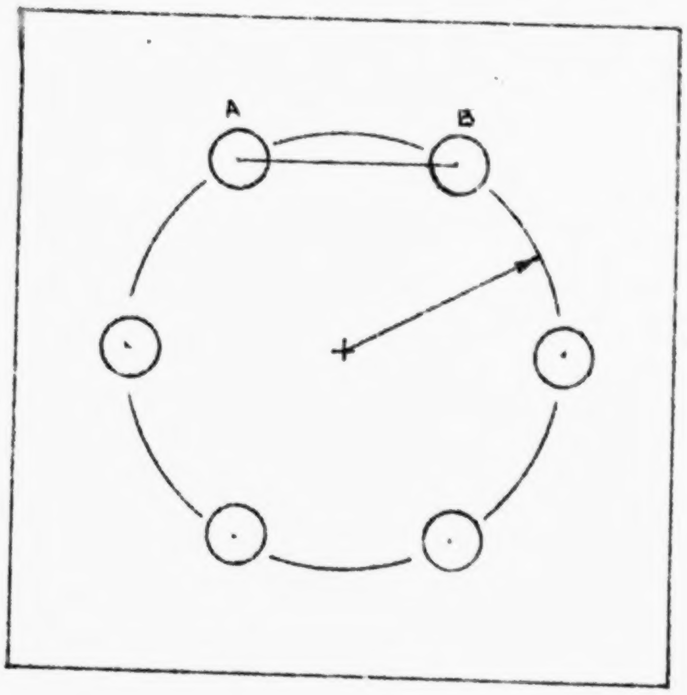
If the angle X is 27° and the gage blocks at B are .775" in height, find H.

4. A countersunk head bolt, shown below, is made according to the dimension shown. Find C to the nearest 32nd of an inch.



(Hint: Cut off two small right triangles top and bottom. Find the side length which is part of C, double it and add $\frac{1}{2}''$.)

5.



On the square plate six small holes are laid out around a circle with radius 6". What is the straight line distance from A to B? (Hint: Draw two more radii by connecting A and B to the center and form a triangle. Then draw a perpendicular from the center to line AB.)

I. Activity: Turning a Taper by Offsetting the Tailstock

II. Objectives: The student should be able to:

A. Describe a taper and how to turn a taper by offsetting the tailstock

B. Determine taper per inch and taper per foot by measurement and computation in formulas

III. Background Information:

A. See Handbook of Applied Mathematics, pages 565 to 572 and the text Chapter 25 for a wealth of information on tapers. Insert as much information in class discussion as the class seems interested in. The types of tapers might be mentioned and/or displayed if available.

B. The most effective introduction to this activity would be a demonstration class in machine shop of taper turning. Since machine shops often cover this topic the shop teacher might be willing to conduct a joint program in which he would teach the shop techniques while you teach the related math. Several arrangements are possible--combination of class, exchange of classes, group work, etc.

C. For this lesson see pages 568-570 of the first mentioned reference.

IV. Materials:

A. Several pieces of metal stock turned into a taper

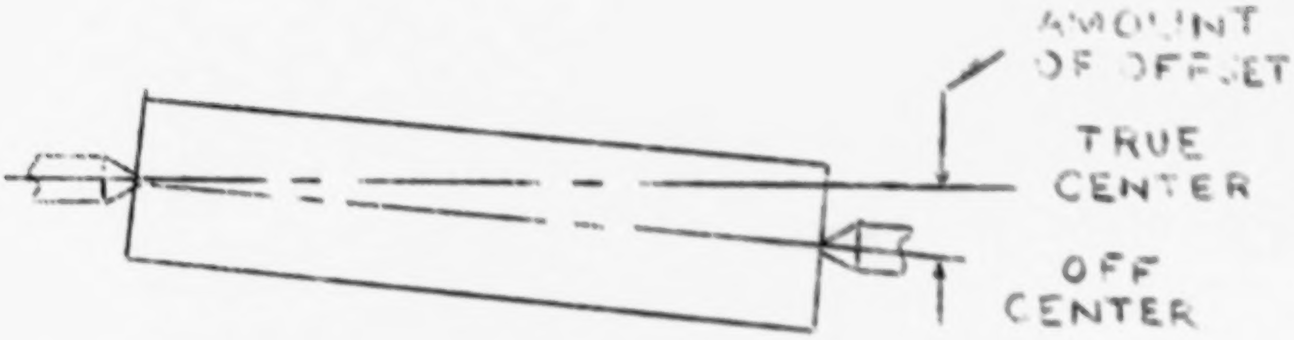
B. Steel scales

C. Opaque projector

V. Suggested Procedure:

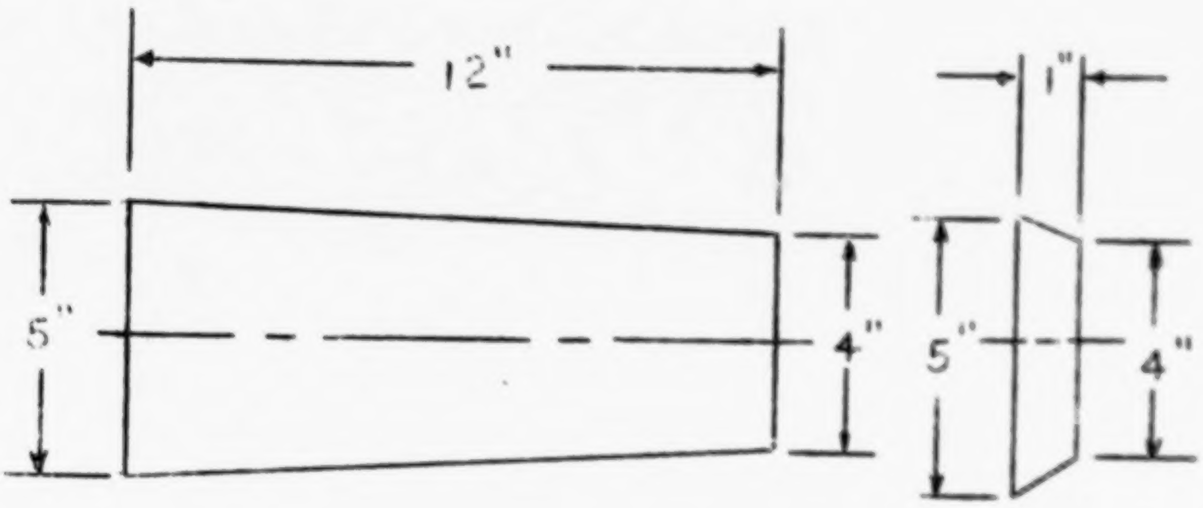
A. Display a tapered piece of stock and give students background information on taper turning. Do not hesitate to discuss method or uses if students ask questions or volunteer comments.

B. Use the opaque projector to show Figure 391 on page 451 of the text. This is the easiest way to specify and show the method of offsetting the tailstock. If the opaque projector is not available use 2 compass points to show the idea and make a drawing on the board. Also refer students to the picture on page 451.



C. Define taper as a gradual and uniform increase or decrease in diameter or thickness. Examples are wedges, any cone, many tools.

D. Put these examples on the board:



Ask how much is each tapered? (1 inch) Which is a sharper taper? Why? How can we describe the difference? (taper per foot and taper per inch) What would the formula for taper per inch be if the large end is D, the small end d and the length L. All measurements are in inches.

$$TPI = \frac{D - d}{L}$$ Do both examples above in taper per inch.

Ask how could the formula be set up for taper per foot?

$$TPF = \frac{(D - d) \times 12}{L}$$ Do both examples above.

E. Have the class work some problems from the text, pages 450-451, numbers 2, 3, 5, 7, 8, 9, 10.

F. Refer back to page 451, Figure 391 and have students consider the process. The explanation on page 451 is excellent.

G. Tell students that the amount of offset is not the same as the taper. Ask why they are different? Explain that when a radius is revolved it turns a circle which has twice the width--a diameter. Therefore, we need only set half the taper. Have students use either formula on page 452, after presenting them to the class. Encourage students to examine the two cases shown in the book.

H. For homework, assign pages 458-459, problems 1, 2, 3, 4, 6, 7, 8.

I. Activity: Turning a Taper Using a Taper Attachment

II. Objectives: The student should be able to:

- A. State two methods for turning a taper
- B. Determine taper per foot (TPF) and taper per inch (TPI)

III. Background Information:

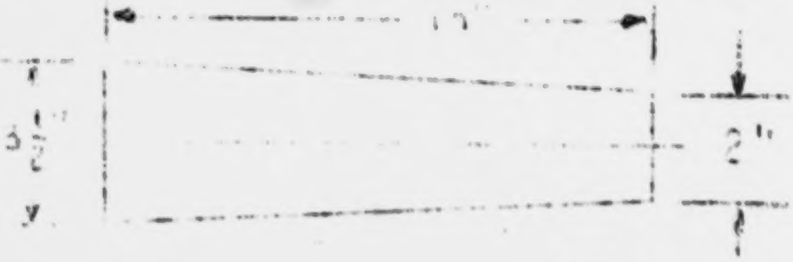
Section 25. 8 on pages 456-458 of the text, with the accompanying drawing and example, is all that the student needs to know about the taper attachment. Once again it will be more meaningful if he has seen it or can see it on the machine.

IV. Materials:

Several pieces of tapered stock

V. Suggested Procedure:

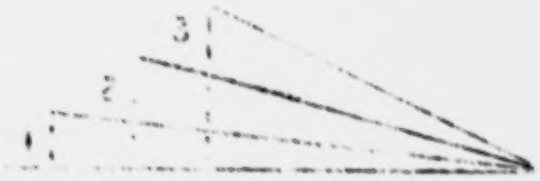
- A. Discuss the "1st Case" on pages 452-453 and "2nd Case" on pages 453-456 with the class.
- B. Discuss the information, Figure 396 and the example in Section 25. 8 of the text.
- C. Work another example for the class at the board.



$$TPF = \frac{(D - d) \times 12}{L} = \frac{(3\frac{1}{2}" - 2" \times 12}{10}$$

- D. Have the class work problems 5 and 9, page 459 and number 15, page 461. It may be necessary to supplement these problems with more of the same type.

E. Discuss the relationship between taper per foot and degrees including the following comments:



What types of triangles are formed? What ratio of sides is involved? Notice the similarity to $\frac{\text{rise}}{\text{run}}$ used for roof pitch. What trig definition would this be?

I. Activity: Turning a Taper Using the Compound Rest

II. Objectives: The student should be able to:

A. Describe a taper and three methods of turning a taper

B. From given information or a drawing of a taper determine the "included angle" or "angle with the center line" using the tangent and trig tables

III. Background Information:

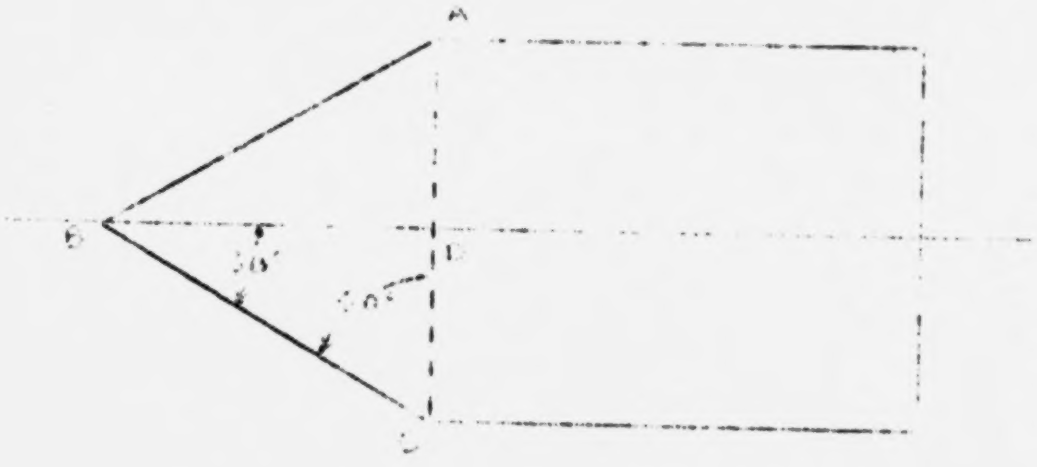
Steep tapers are usually given as angles. When the angle is less than 10° it is designated as a taper. Angles larger than 10° are given as the "included angle" or as the "angle with the center line." See Section 25. 9 on page 458 of the text. Again the lesson will be more meaningful if the student can see the compound rest and the graduation in degrees on the lathe.

IV. Materials:

Booklet--Handy Multipliers and Trig Tables for Engineers

V. Suggested Procedure:

A. Review the two previous methods of turning a taper and introduce the final method--using a compound rest. Again compare taper per foot with an angle as in the lesson on the taper attachment. Use the same questions if necessary until students see that taper per foot is the same ratio as the tangent definition.



Put the drawing on the previous page on the board and point out angle ABC as the included angle and b as the angle with the center line.

C. Have students state the ratio for tangent b. $(\frac{DC}{BD})$ Give the class the formula $\tan b = \frac{TPF}{24}$.

D. Work a problem for the class where $TPF = \frac{1}{2}''$. Pass out the trig table booklets and have the class find the angle from the decimal you have computed.

E. Give the class a second formula used when TPF is not known:

$$\tan b = \frac{D - d}{2L}$$

F. Work an example for the class where: $D = 1\frac{1}{8}''$, $d = \frac{1}{2}''$ and $L = 1\frac{1}{4}''$. Again have the class use the tables to give the answer.

G. Since b (the angle with the center line) has been found in both cases, ask what the included angle should be in both cases?

H. Assign the work sheet, "Turning a Taper Using the Compound Rest."

TURNING A TAPER USING THE COMPOUND REST

Directions: 1. Select the formula needed

$$\tan b = \frac{TPF}{24} \quad \text{or} \quad \tan b = \frac{D - d}{2L}.$$

2. Find the angle with the center line and the included angle.

D	d	L	TPF	Angle with the Center Line	Included Angles
$3\frac{1}{4}$"	$2\frac{1}{4}$"	6"	---		
4.875"	3.125"	10"	---		
6.250"	4.625"	7"	---		
5.500"	4.100"	12"	---		
4.250"	2.875"	30"	---		
---	---	---	$\frac{1}{4}$"		
---	---	---	$\frac{3}{8}$"		
---	---	---	$\frac{7}{16}$"		
---	---	---	$\frac{5}{8}$"		
4"	3"	16"	$\frac{3}{4}$"		

I. Activity: The Sine Bar from Industry

II. Objectives: The student should be able to:

A. Use trig and the sine ratio specifically to solve an applied problem

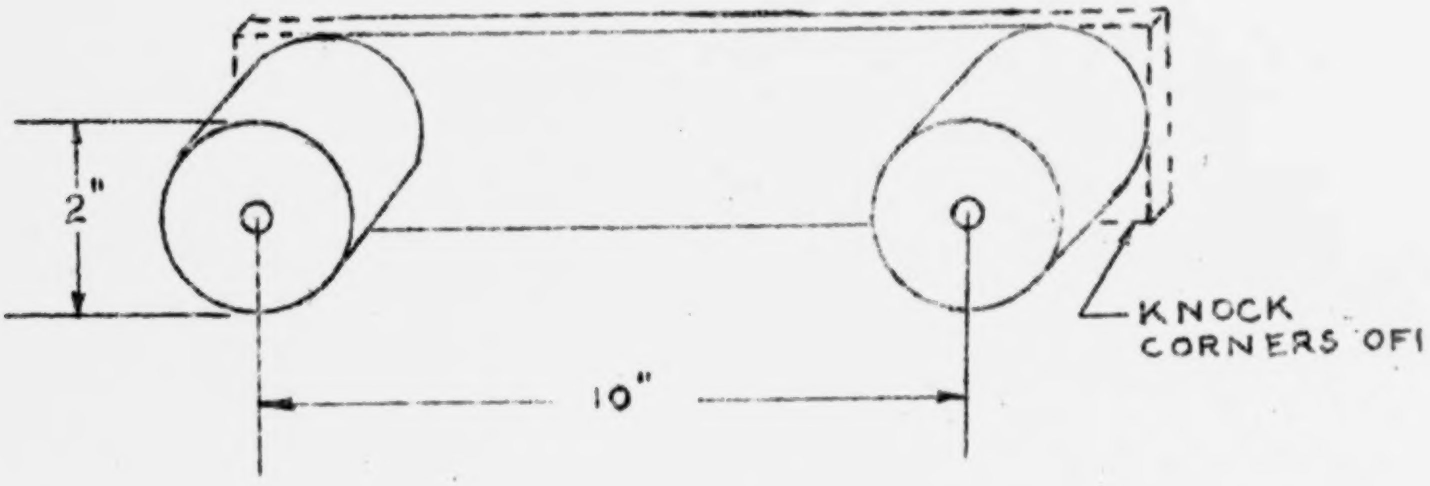
B. State the procedure for the use of a sine bar

III. Background Information:

The sine bar is used in industry for precise measurements of the angle of a taper. See pages 571-573 in the Handbook of Applied Mathematics for details. The essential ideas are that the bar pivots on one end and that the length (hypotenuse) is 5" or 10" to simplify computation. A precise height gauge measures the elevation of the other end. A working model made of wood would be excellent for demonstration purposes. The model could be prepared by a student prior to the teaching of this lesson.

IV. Materials:

Homemade wooden sine bar, yardstick or 12" ruler



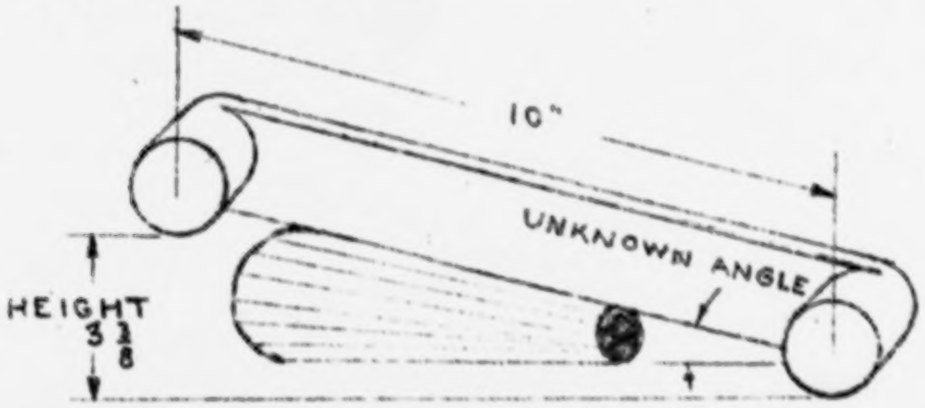
V. Suggested Procedure:

A. Display the homemade sine bar and give some description from the suggested reference. A more elaborate drawing on the board or projection with an opaque projector from a picture would be effective for explanation.

B. Explain to the students that it is very simple and quick to use and that it will be easy to understand now that they know some trig.

C. Arrange several books so that they form an acute angle incline or use an object that has a taper to it. State that we want to determine the angle of taper or slope and that an industrial sine bar is much more accurate than a protractor.

D. Place the sine bar so that the surface is flat against the taper. Make a drawing on the board also. Point out the unknown angle.



E. Ask the class what we know about this triangle with respect to the unknown angle. (The class should say opposite side and hypotenuse.) Then ask which trig function involves these two sides.

F. Measure the height with a yardstick or ruler to the nearest 8th or 16th inch. Have students set up the ratio:

$$\sin \underline{\qquad\quad} = \frac{3\frac{3}{8}''}{10''} = \frac{3.375}{10}$$

Have students supply the decimal equivalents as above. Ask what effect division by ten (10) has. Then have the class consider:

$$\sin \underline{\qquad\quad} = .3375$$

G. Pass out the trig booklets and tell the class to find the angle Review the process.

H. Give the class about six height readings and demonstrate each one with the homemade sine bar. Have them estimate the angle by eye, record it by the height reading, then determine the angle using trig.

I. Activity: Connector Fittings

II. Objectives: The student should be able to:

A. Inscribe a circle in a regular hexagon

B. Find the length of a side of a regular hexagon given the diameter of the circumscribed circle

C. Use a given factor to find the diameter of the circle inscribed in a given regular hexagon

III. Background Information:

On pages 465-466 of the text there are three excellent drawings which should be referred to during the latter part of the lesson. The part labeled number 12 in the micrometer kit is an example of a connector fitting.

IV. Materials:

A. Compasses

B. Steel scales

C. Connector fitting

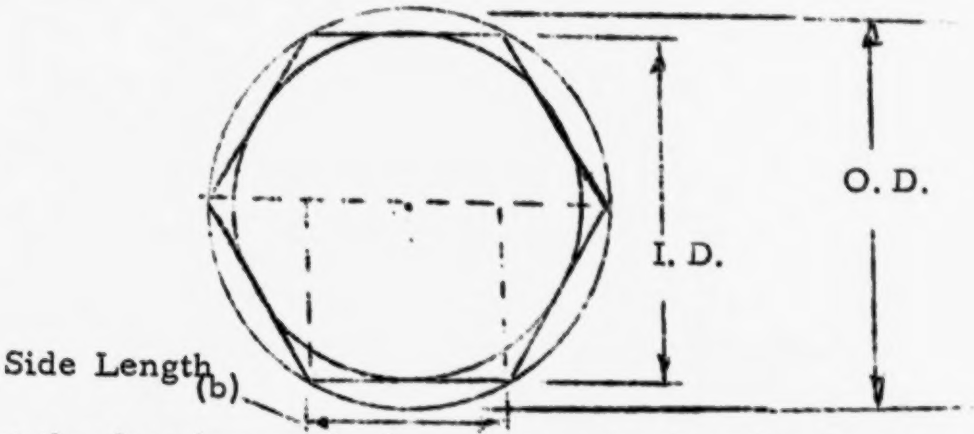
D. Work sheet entitled, "Circles in Hexes"

V. Suggested Procedure:

A. Display the connector fitting and emphasize that the circle fits in (is inscribed in) the hexagon. There are two such examples in the micrometer kit. Pass out the compasses and have students construct hexagons by using the radius of a circle and inscribing the hexagon.

B. Ask students what the diameter of an inscribed circle should be. They should recognize that it is the same as the distance across the flats. Ask how we would draw the inscribed circle. Pass out steel scales and have students measure distance across the flats, halve it, set the radius and draw the inscribed circle.

Ask students how to find the center of a hexagon. Have students do two more such problems using 2 different size circles.



C. Put the drawing on the board as a check and to introduce a new problem: "What should the side length (b) be?"

D. Add the dotted lines shown above and have students guess the length of b compared to other distances. Tell them that b = $\frac{1}{2}$ of OD or OD = 2b. Refer to the activity "Making a Hex Nut" and the fact that OD = 1.155 x distance across the flats (d). Therefore, 2b = OD = 1.155 x d. In making a hex nut then, a good check would be to determine the side length b then measure the hex nut for accuracy.

E. Have students make drawings for and complete the following work sheet.

CIRCLES IN HEXES

Formulas: OD = 2b = 1.155 x d

Instructions: Draw two circles in the space below. One should have a diameter of 1", the other $2\frac{1}{2}$". Inscribe a hexagon in each, then inscribe a circle in each hexagon. Determine the dimensions specified below for each. Then measure to the nearest 32nd inch to check.

	Small Circle	Large Circle
1. Distance across the flats (d)		
2. Radius of outside circle (r)		
3. Diameter of inside circle (ID)		
4. Length of hexagon side (b)		

RELATED APPLIED ACTIVITIES

I. Activity: Low Bid--A Game for Prospective Contractors

II. Objective: The student should be able to:

Apply the rules for basic operations within the game format

III. Background Information:

The major objective of Low Bid is to become the wealthiest player after ten years (rounds) of bidding on various jobs. To accomplish this a player must consistently bid lower than his competitors without going below the actual cost of a job.

Terms:

Labor--The estimated wages for employees for a given job
Material--The estimated cost of materials for a given job
Bid--A skilled estimate of all costs
Profit--Amount bid minus actual cost if the amount bid is larger
Loss--Actual cost minus amount bid if the actual cost is larger

IV. Materials:

A. Game sheets entitled, "Low Bid" and "Jobs-Year 1-10"

B. List of actual costs of jobs

C. Transparency of sample Low Bid sheet

V. Suggested Procedure:

A. Study the rules of the game as explained under Play below.

B. Low Bid is designed to be played with small groups of students. However, it is suggested that the rules be explained during a round played with the class under the teacher's direction. A transparency of the sample "Low Bid" sheet should be used.

C. The Setup
Divide the class into groups of 3 to 5 players. Each player is then given a game sheet entitled, "Low Bid," and a sheet entitled, "Contractor's Jobs-Year ." Each player has $100,000 as capital available to start the game in year one. The teacher will have the actual cost for each job.

D. The Play

Each player records the labor and material costs for each job in the appropriate space on the "Low Bid" sheet. Each player then determines the total estimated cost for each job and enters it in the appropriate space.

The bidding is now ready to begin. Each player should examine the total estimated cost for each job. Then each player should decide whether or not he wants to bid on that job. If a decision to bid is reached, the bid should be written in the "Amount Bid" column opposite that job. Note: contractors frequently avoid bidding on a job when the estimated labor cost exceeds the estimated materials cost.

When all players have recorded their bids each group should discuss the bids for each job and decide upon the Low Bidder. The low bidder should place a check in the column headed "Low Bidder?" opposite the appropriate job. If there is a tie for low bidder, decide by a toss of a coin.

When each group has decided upon a low bidder for each job, the teacher reveals the actual cost for each job. The low bidders in each group should record this in the column headed "Actual Cost."

The low bidders will then compute their profit or loss. Record profit with a "+" sign and loss with a "-" sign in the column headed "Profit or Loss."

After all profits and losses have been recorded each player should compute and record the following:

1. The total amount of bids.
2. Estimating and bidding costs (1% of the total amount bid)
3. Total actual cost
4. Administrative expenses (2% of the actual cost of the jobs received)
5. Capital charges (10% of available capital)
6. Fixed costs ($20,000 per year)

7. Total expenses (sum of estimating and bidding costs, administrative expenses, capital charges and fixed costs)
8. Profit or loss from jobs received
9. Gross profit or loss before taxes, i.e. difference between profit and total expenses or the sum of loss and total expenses.
10. Income taxes (40% of gross profit)
11. Net profit or loss (gross profit less income tax)
12. Capital available at the end of the year (beginning capital plus net profit or minus net loss). This will be carried over to the next year.
13. For additional clarification see the sample Low Bid sheet. If necessary, players may complete the record keeping as a home assignment.

E. At the completion of year one the Low Bid sheets should be collected. Rank the players according to the amount of capital available for the next year. The groups for year two can then be formed from this ranking.

The game continues for ten years (rounds). At the end of this time the winner will be the player with the greatest amount of capital available.

SAMPLE
LOW BID

Year 1

JOBS AVAILABLE — JOBS BID — JOBS RECEIVED

Job No.	Estimated Direct Cost			Actual Bid	Low Bidder?	Actual Direct Cost	Profit or Loss
	Labor	Materials	Total				
1	40,000	60,000	100,000	115,000			
2	60,000	60,000	120,000	–			
3	75,000	50,000	125,000	–			
4	100,000	150,000	250,000	280,000			
5	500,000	1,000,000	1,500,000	1,650,000			
6	300,000	450,000	750,000	770,000	✓	720,000	+50,000
7	50,000	75,000	125,000	130,000			
8	200,000	300,000	500,000	530,000			
9	400,000	200,000	600,000				
10	250,000	250,000	500,000	510,000	✓	460,000	+50,000
Total				3,985,000		1,180,000	+100,000

Capital available at the beginning of the year.......................... $ 100,000

Annual Operating Summary

(1) Estimating and bidding costs (1% of total amount bid).................... $ 39,850

(2) Administrative expenses (2% of actual direct cost of jobs received)............... $ 23,600

(3) Capital charges (10% of available capital).. $ 10,000

(4) Fixed costs ($20,000 per year)............ $ 20,000

TOTAL EXPENSES (sum of 1, 2, 3, and 4). $ 93,450

Profit or loss from jobs received.......... $ +100,000

Gross profit or loss before taxes.......... $ +6,550

Income taxes (40% of gross profit)......... $ 2,820

Net profit or loss (gross profit, less income taxes.......................... $ 3,730

Capital available at end of year (beginning capital profit or loss; to be carried over to beginning of next year).......................... $ 103,730

Joe Student
Contractor's Signature

LIST OF ACTUAL DIRECT COSTS FOR JOBS

JOB	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
1	87,000	120,000	150,000	120,000	94,750	128,000	35,000	110,000	280,000	350,000
2	111,000	1,000,000	300,000	165,000	116,800	80,000	50,000	120,000	2,100,000	2,100,000
3	123,000	450,000	140,000	2,000,000	43,500	89,500	536,000	125,000	730,000	155,000
4	245,000	600,000	260,000	16,500	55,000	211,800	235,000	246,000	650,000	1,030,000
5	1,500,000	2,500,000	2,000,000	105,000	66,500	1,750,000	116,000	1,900,000	115,000	65,000
6	800,000	180,000	3,750,000	248,000	123,400	830,000	150,000	640,000	420,000	170,000
7	585,000	175,000	24,000	350,000	980,000	825,000	1,148,000	530,000	135,000	20,000
8	480,000	240,000	92,000	59,800	380,000	380,000	720,000	140,000	100,000	80,000
9	120,000	500,000	185,000	28,750	246,500	196,000	350,000	250,000	440,000	140,000
10	480,000	225,000	260,000	175,000	60,000	430,000	200,000	675,000	139,000	2,190,000

LOW BID

Year ____________

JOBS AVAILABLE				JOBS BID		JOBS RECEIVED	
Job No.	Estimated Direct Cost			Actual Bid	Low Bidder?	Actual Direct Cost	Profit or Loss
	Labor	Materials	Total				
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
Total							

Capital available at the beginning of the year........................ $ ____________

Annual Operating Summary

(1) Estimating and bidding costs
(1% of total amount bid).................. $ ____________

(2) Administrative expenses (2% of actual
direct cost of jobs received).............. $ ____________

(3) Capital charges (10% of available capital).. $ ____________

(4) Fixed costs ($20,000 per year)............ $ ____________

TOTAL EXPENSES (sum of 1, 2, 3, and 4). $ ____________

Profit or loss from jobs received.......... $ ____________

Gross profit or loss before taxes.......... $ ____________

Income taxes (40% of gross profit)......... $ ____________

Net profit or loss (gross profit, less income taxes...................... $ ____________

Capital available at end of year (beginning capital profit or loss;
to be carried over to beginning of next year)......................... $ ____________

____
Contractor's Signature

JOBS--YEAR 1

	LABOR	MATERIALS
1. Service Station	$40,000	$60,000
2. Luxury Home	60,000	60,000
3. Television Tower	75,000	50,000
4. Office Building	100,000	150,000
5. School	500,000	1,500,000
6. Factory Addition	300,000	450,000
7. Medicine Center	400,000	200,000
8. Drug Store	250,000	250,000
9. Apartment House	50,000	75,000
10. Bridge	200,000	300,000

JOBS--YEAR 2

	LABOR	MATERIALS
1. Luxury Home	$60,000	$65,000
2. Theater	750,000	1,500,000
3. Development (Homes)	200,000	300,000
4. Department Store	250,000	300,000
5. Hospital	1,000,000	2,000,000
6. Plumbing Supply Co.	80,000	120,000
7. Public Address System	100,000	100,000
8. Research	150,000	100,000
9. A & P	200,000	350,000
10. Convalescent Home	100,000	150,000

JOBS--YEAR 3

	LABOR	MATERIALS
1. Remodeling	$75,000	$90,000
2. Civic Center	125,000	187,500
3. Cleaning	60,000	90,000
4. Glass Company	150,000	100,000
5. Holiday Inn	750,000	1,500,000
6. Research Laboratory	1,500,000	2,500,000
7. Typewriter Repairs	10,000	15,000
8. Pier	50,000	40,000
9. Roofing	80,000	100,000
10. Garbage Disposal	140,000	150,000

JOBS--YEAR 4

	LABOR	MATERIALS
1. Fire Repairs	$50,000	$70,000
2. Packing	80,000	80,000
3. School	900,000	1,300,000
4. House	7,000	10,000
5. Water Conservation	45,000	65,000
6. Insulation	110,000	150,000
7. Dam	175,000	210,000
8. Timing System Repair	25,000	40,000
9. Home	16,000	14,000
10. Air Pollution System	86,500	93,500

JOBS--YEAR 5

	LABOR	MATERIALS
1. Equipment Repairs	$45,800	$50,400
2. Drug Store	58,350	60,650
3. Snow Removal	20,000	30,000
4. Remodeling	30,000	30,000
5. Painting	37,500	25,000
6. Sand Blasting	50,000	75,000
7. Cement Work	250,000	750,000
8. Air Conditioning	150,000	225,000
9. Damages	125,000	125,000
10. Tree Removal	25,000	37,500

JOBS--YEAR 6

	LABOR	MATERIALS
1. Farm Building	$62,000	$68,000
2. Glass Company Office	36,400	42,800
3. Electrical Repairs	43,540	50,270
4. Truck Repairs	102,000	116,000
5. Highway	600,000	1,450,000
6. Tunnel Approach	300,000	550,000
7. Steel Construction	350,000	480,000
8. Design Work	186,000	202,000
9. Planning	96,400	100,000
10. Plumbing	228,000	200,000

JOBS--YEAR 7

	LABOR	MATERIALS
1. Land Development	$15,000	$20,000
2. House	27,500	32,800
3. Air Conditioning a School	240,000	300,000
4. Store	116,000	120,000
5. Restaurant	60,400	56,300
6. Motel	74,200	80,500
7. Hotel	560,000	600,000
8. Road Construction	320,000	408,000
9. Pipe Line	176,000	184,000
10. Swimming Pool	96,480	110,650

JOBS--YEAR 8

	LABOR	MATERIALS
1. Hurricane Damage Repairs	$48,000	$65,000
2. Research Facility	56,000	62,000
3. Service Station	72,600	51,750
4. Food Services Center	98,000	148,000
5. Steel Construction for Factory	740,000	1,250,000
6. Office Building	356,000	285,000
7. Civic Center Addition	228,000	306,000
8. Playground	64,000	73,000
9. Motel	161,000	200,000
10. Swimming Pool	405,000	275,000

JOBS--YEAR 9

	LABOR	MATERIALS
1. Office Building	$127,000	$158,000
2. Super Market	720,000	1,400,000
3. Warehouse	308,000	425,000
4. Bus Terminal	398,000	256,000
5. Farm Building	52,500	63,700
6. Road	210,000	208,000
7. Electrical Repairs	67,000	65,000
8. Roofing	45,000	70,000
9. Medical Center	197,000	260,000
10. Public Address System	78,400	60,000

JOBS--YEAR 10

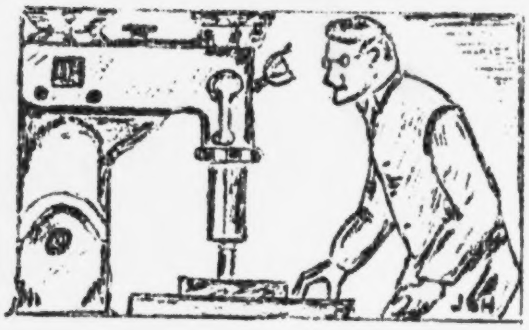
	LABOR	MATERIALS
1. Factory Addition	$160,000	$187,000
2. Sewage Disposal Plant	650,000	1,420,000
3. Service Station	68,000	100,000
4. Pier	480,500	600,000
5. Bulkhead	32,800	40,200
6. Research Building	109,000	148,000
7. Custom Home	10,450	18,500
8. Roofing Repairs	37,000	43,000
9. Fire Damage Repairs	75,000	60,000
10. Stadium	983,000	1,287,000

APPRENTICESHIP INFORMATION

Considerable information is available concerning the various apprenticeship programs. Students in the applied mathematics classes should be made aware of these opportunities. The booklet entitled, "The National Apprenticeship Program-1966 Edition," is available in the mathematics office. This booklet should prove particularly helpful in explaining the basic ideas of the program. Additional information may be obtained by contacting the field representative of the United States Department of Labor, Bureau of Apprenticeship and Training at 962-2676. The field representative will be willing to meet with the guidance department to familiarize the counselors with the program.

An apprenticeship program is also in effect at the Bethlehem Steel Corporation, Sparrows Point, Maryland. The following sheet explains the necessary information.

BETHLEHEM STEEL CORPORATION
SPARROWS POINT, MD.



You will be paid for attending classes.

You will learn to use tools like an expert.

You will get a raise every six months.

Apprenticeship Opportunities

Blacksmith
Bricklayer
Carpenter
Coremaker
Electrician (Shop)
Electrician (Wireman)
Erector
Lineman (Electrical)
Machinist
Moulder
Patternmaker
Pipefitter
Roll Turner
Sheet Metal Worker
Toolmaker
Electronic Repairma

Requirements for Admission

(a) Age: At least 18 years of age
(b) Citizenship: American
(c) Health: Good (subject to physical examination)
(d) Education: High School or equivalent education
(e) Tests: In order for an applicant to qualify for an apprenticeship. in addition to the previous conditions, he must achieve at least minimum qualifying scores on a series of tests measuring mental ability, mechanical comprehension, English grammar, general mathematics, algebra, shop knowledge, general science and mechanical drawing.

How to Apply for Apprenticeship

If the facts briefly presented above are of interest to you, apply at the Employment Office of the Bethlehem Steel Corporation, Sparrows Point, between the hours of 8:00 A.M. and 3:00 P.M. Be sure to mention the fact that you are primarily interested in the Apprentice Program.

AN EQUAL OPPORTUNITY EMPLOYER

Length of Apprenticeship

There is an initial probationary period of 500 working hours (about three months). If both parties are satisfied with the progress made at the end of that period of time, an agreement is made to complete the additional hours required for graduation. A total of 8000 working hours (approximately four years) is required in most trades.

The period of apprenticeship is divided as follows:

A. Shop work, in which the apprentice learns by doing, under close supervision, according to a prearranged schedule of operations designed to develop all-around craftsmen.

B. Classroom work, four hours per week during the regular work shift, at the regular hourly base rate, at which time the apprentice is instructed in subjects related to his trade, such as blueprint reading, mechanical drawing, mathematics, shop theory, etc.

Pay Raises

All apprentices in the Steel Plant, regardless of which trade they choose, are paid the same hourly rate, which progresses during their training. Automatic increases are granted every 1000 hours while the apprentice is serving his trade, followed by promotions to the "A" grade craftsman after graduation.

Completion of Training

The apprentice successfully completing an apprenticeship receives $200.00 bonus, a diploma, and a photostatic wallet size copy of the diploma as permanent evidence that he has served his trade.

AN EQUAL OPPORTUNITY EMPLOYER

CAREERS IN CONSTRUCTION

A Filmed Presentation

An excellent film entitled "Careers in Construction" is available through the Associated Builders and Contractors, Inc. Mr. Ronald A. Woerner, Assistant Executive Director of the Baltimore Metropolitan Chapter has indicated a willingness to assist us in the use of the film. Mr. Woerner will attempt to arrange for contractors to come to the schools, show the film, and apeak with groups of applied mathematics students about the various trades. To make the necessary arrangements Mr. Woerner may be contacted at 823-5845.

"MAN ON THE JOB" Taped Interviews

Teacher Commentary

These interviews consist of taped, unrehearsed conversations with men working in or dealing with various trades. If the students hear the description of various trades from men in these trades, and while they are on the job, then a greater level of realism may be brought into the classroom. The tapes may be used as a motivating device at the beginning of a unit, as supplementary material during the course of the unit, or as a culminating activity. The teacher should listen to the tapes before using them in the classroom.

In all interviews an effort was made to discuss the following:

1. A description of the job, trade, or corporation represented
2. Qualities and prerequisites necessary to be employed
3. Opportunities available in the specific trade
4. Relation of mathematics to the specific trade
5. Advice for tenth grade students from the person being interviewed.

The detail of each tape will be best appreciated when the tape is preplayed, but some general background information follows:

1. Building contractor--Mr. Donald Chenoweth, Lester G. Chenoweth & Sons--One of the most difficult to understand due to background noise; try keeping recorder as far from class as possible when playing as this seems to help. Mr. Chenoweth points out the need for measurement skills as a carpenter.
2. Plumber--Mr. Christian Wild, Christian G. Wild & Sons--Mr. Wild discusses the various stages of training necessary to becoming a master plumber. Also mentions use of mathematics.
3. Diecraft Corporation--Mr. Robert Duncan, machine shop supervisor and Mr. Joe Madden, quality control inspector; teacher should remain close to volume control as Mr. Madden's voice fades at times.

4. Diecraft Corporation--Interviews taped in machine area; therefore, a loud background; Mr. Joe Marshall, milling machine foreman and Mr. Ed Weisberg, electro-plating foreman discuss their work.
5. Bethlehem Steel Corporation--Mr. Charles Edgehill, machinist and teacher in apprentice program. Mr. Edgehill gives an excellent description of an apprenticeship program.
6. Bethlehem Steel Corporation--Mr. John Helbing, machinist and teacher in apprenticeship program.
7. Service station manager--Mr. Kenneth Smith--Good comments on use of mathematics, value of good personal appearance and the metric system.
8. Building contractor--Mr. Thomas Gentry--Slides accompany this tape. Mr. Gentry narrates the various phases of the construction of a house.

I. Activity: I'd Walk a Mile...

II. Objectives: The student should be able to

Find approximate distances by counting paces

III. Background Information: The lesson is divided into three segments:

A. Explanation of the pacing method and directions for the last two segments

B. Movement of the class outside to the football field to measure the students' average number of normal paces for 100 measured yards

C. Pacing off distances to estimate solutions for certain practical problems

This topic can be incorporated with surveying or area measure.

IV. Materials:

A. Paper

B. Pencil

C. Hard surface to write on outdoors

V. Suggested Procedure:

A. Tell the class that approximations are sometimes needed instead of exact measurements in big areas. To obtain a quick estimate for grass seed cost, acreage check, or just estimate distance for golf club selection, a basic method is needed. (Encourage some discussion here.) Have the class suggest some simple methods. They may suggest estimation by eye, but this takes experience. Also, it will be easy to show how difficult it is to estimate by eye when the class is taken outside. If no one suggests pacing, mention that we have the measuring instrument very handy--our legs.

B. Discuss pacing with the class: A person's stride may be long or short compared to another, but it is usually consistent in length. If the number of strides taken to walk a given distance (100 yards) were known, then it would be possible to determine an average pace.

Several factors affect pacing: A natural stride can be maintained while a forced stride will vary in length. Strides uphill will be shorter, strides down hill longer. Strides at night are shorter as are strides when tired. Have the class suggest other factors.

C. Explain that each person must determine his own personal pace factor. Set up a situation where a person takes 110 paces, 112 paces, and 113 paces in walking a measured 100 yards. Ask,"What is his pace factor?" (Students should average on paper or mentally.) Discuss the averaging procedure briefly.

D. Explain the process to follow: The class will go outside to the football field (or track or premeasured course). The class will start pacing from the start line, counting the paces to the end line. (Stress that the stride must be natural.) They will stop at the other end, record the number, and pace back. They will repeat this again, down and back. Then the numbers will be averaged to get a pace factor.

E. With the pace factor recorded there are two alternatives. Based on time available decide whether to take the class in and summarize or to assign some practical problems.

F. The practical problems should be given in a natural setting; i.e. word problem or verbal description. The student should--with some advice--analyze, set up and solve the problems.

G. Problems will be hypothetical, but realistic in that approximate distances may be used and can be measured on school property. Some suggested problems are:

1. Pace to determine the length of each hallway in the building.
2. Pace to determine the length of one wall of a building of the school. Find the perimeter of the entire building.
3. Pace to find the distance around the school grounds.

4. Pace the distance home (walkers).

5. Pace the perimeter of your house or apartment building.

6. Pace the distance from home plate directly to second base on the baseball diamond.

7. Pace the distance around the track oval in the inside lane. Do the same thing for the outside lane.

8. Pace the length of sidewalk on school property and compute the total.

H. Other, more involved,applied problems which require pacing can be used. A few are suggested below:

1. Measure by pacing adjacent (different) sides of a rectangular area. Use the lengths to find square foot and compute the cost to plant seed. The price may be given or found in a catalog. Also a price for sodding might be computed and compared. Fertilizer or lime requirements might be added also.

2. Sketch a layout for one hole of a golf course. The tee and hole should each be pinpointed on a easily discernible object (e.g. the tee might be at a backstop, the hole at the pitcher's mound on another diamond). What would the length of the hole be in yards? Check to see what the par should be for that length. Make the same hole into a dogleg.

3. Locate positions for foul poles if they should be 300 feet from home plate on the baseball field. What is the distance between these two foul poles?

4. How many square feet do the tennis courts cover? Investigate to find a price to pave this with concrete? macadam?

CATALOG CARDS

Teacher Commentary

The purpose of this kit is to provide practice in mathematics through practical applications. Each of the problem cards reviews and reinforces the fundamental operations with whole numbers, fractions and decimals, interpretations of scale drawings, and finding area.

I. **Materials:**

   A. Catalog Cards Kit consisting of:

      1. 41 problem cards separated into three categories

         a. Cards labeled A1-A12 which place limits on the amount of money to be spent

         b. Cards labeled B1-B12 for which the amount of money to be spent is unlimited

         c. Cards labeled C1-C17 for which the student must compute an area, determine the number of yards of material, etc. before he can calculate the total cost

      2. Reference cards labeled D1-D4 with floor plans to be used with problem cards

      3. Order forms

II. **Suggested Procedure:**

   A. Students should bring in as many catalogs as possible from Sears, Wards, Speigel, etc. The catalog cards are designed to be used with any catalog.

   B. Work with the catalog cards may be varied as follows:

      1. Student may order parcel post (mailable items only) where he will have to use the chart to find the cost of postage.

      2. Student may list shipping weights and be required to find total.

3. Student may be allowed to make up any original problem of his own.

4. Student may order items to be sent to other states where the tax rate differs.

5. Student may pay on the extended payment plan where he agrees to pay a specified amount each month until his debt is paid. In this case the student must complete the credit application.

C. The teacher should spend some time demonstrating how to use a catalog. Although students might know how to use the index to find specific items, they will need guidance in reading tables, interpreting prices, calculating tax, and completing an order form.

D. To introduce this activity, the teacher should distribute copies of the order form and a work sheet in which the catalog number, name of item, color or size and price per item are given. Since each teacher can better determine which items might be of interest to his particular class, the work sheet is not included. After deciding with the class how many of each item will be bought, students should use this information to complete the order form. Check the results with the class.

E. Once students know how to complete the order form, they should work the problem cards individually or in groups of two. Students should work at their own rate.

F. Since all order forms are approximately the same, the students should use the order form provided, regardless of the catalog they are using to obtain their information.

G. Students should complete at least four of the cards A1-A9 before trying cards A10, A11, or A12 of the set. In these cards not only are limits placed on the amount of money spent, but also lists of necessary furnishings are given. Thereafter, students should select cards which are of particular interest to them.

H. Students should not be required to complete all of the catalog cards. The teacher and student should create additional problem cards.

I. Collect order forms as they are completed. Because the students will be using catalogs from different companies or different editions from the same company, there is no way to standardize the prices. One major objective is for students to use the catalog before figuring the costs. Therefore, the teacher should evaluate the students' work by spot-checking the order form, looking for reasonable prices, catalog numbers and totals. For those cards in which a student must compute area, a close check of his work sheet is required.

J. If additional cards or order forms are required, they can be produced by obtaining the master copies found in the guide entitled, "Mathematics for Basic Education Grade 10."

Computational Activities

COMPUTATIONAL ACTIVITIES

FINDING MISSING DIMENSIONS

The following four drawings involve the finding of unknown dimensions. They may be used as drills, quizzes, or homework exercises. For each drawing there are:

4 problems on whole numbers
8 problems on fractions
8 problems on decimals
8 problems on fraction-decimal combinations.

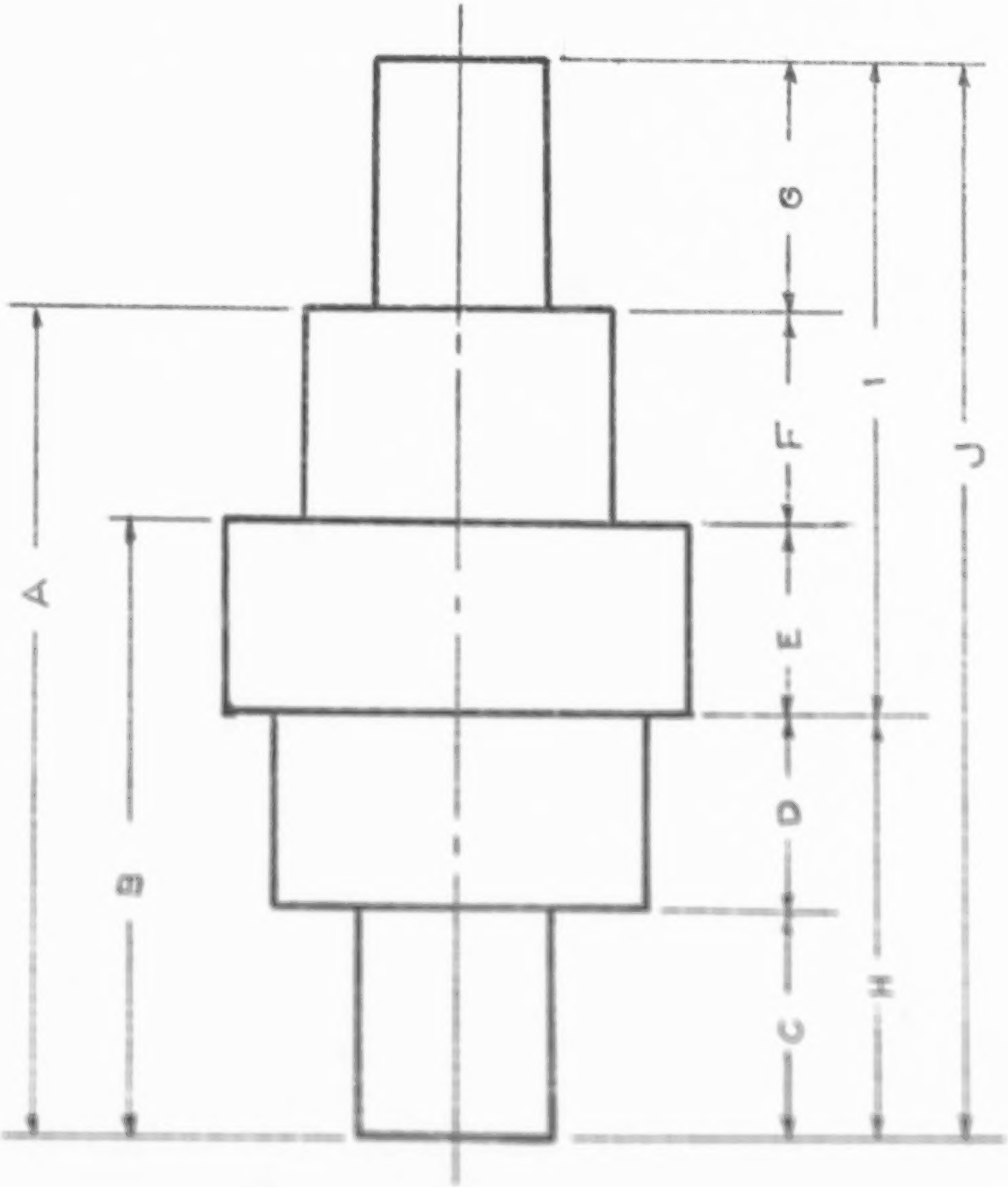
These drawings may be used to reproduce transparencies to be used with an overhead projector or to reproduce student copies.

Example: Refer to problem-answer sheet for
Drawing Number 1
Whole Numbers
Set I

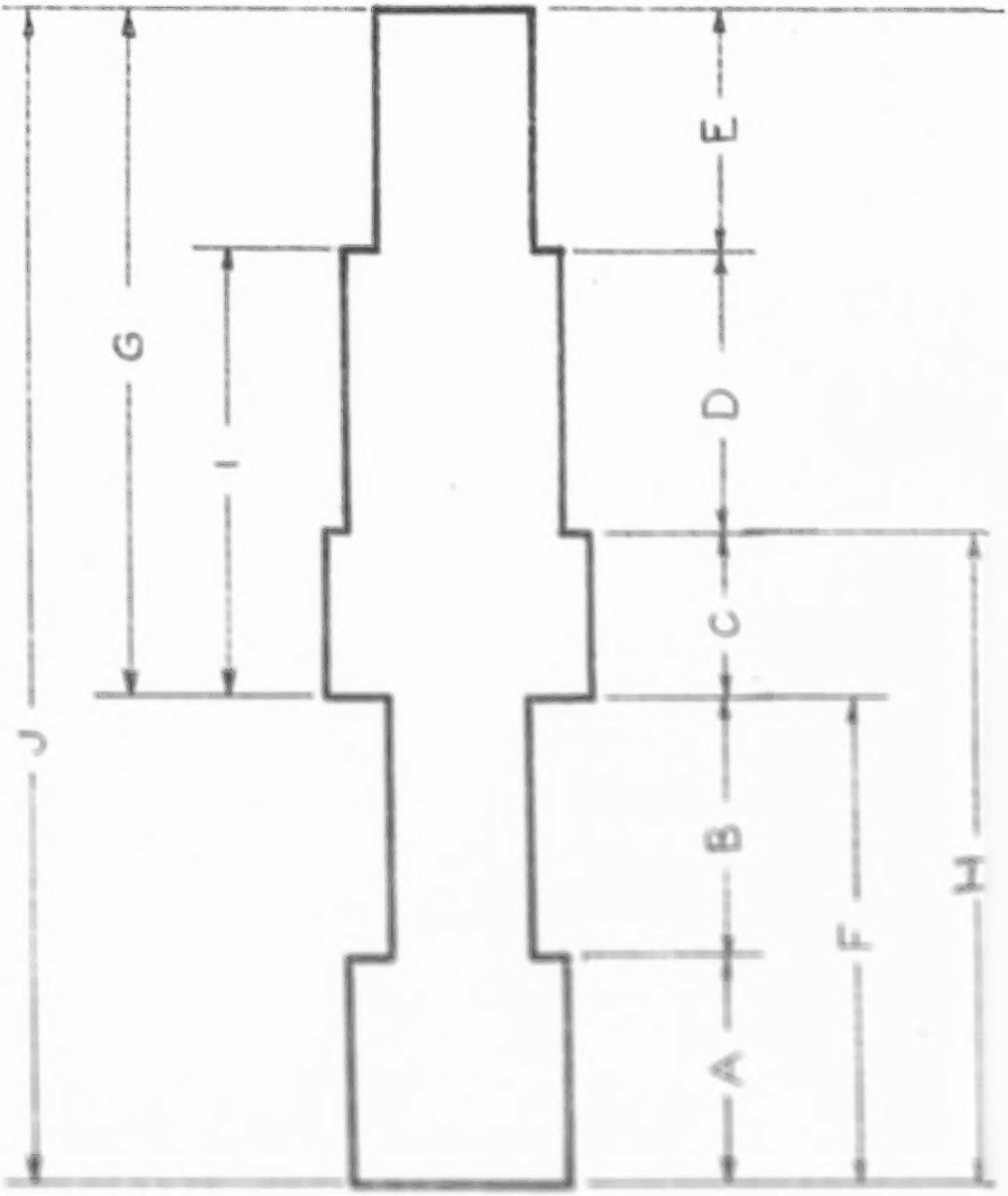
The following numerical values: C = 46; D = 25; E = 29; F = 42; and G = 44 should be written above the given letters on the transparency with a transparency pencil. The students will then find the numerical values for A; B; H, I, and J.

When using student copies of the drawings the teacher can give the students the above values with instructions to write the numerical values above the letters and then find the unknown.

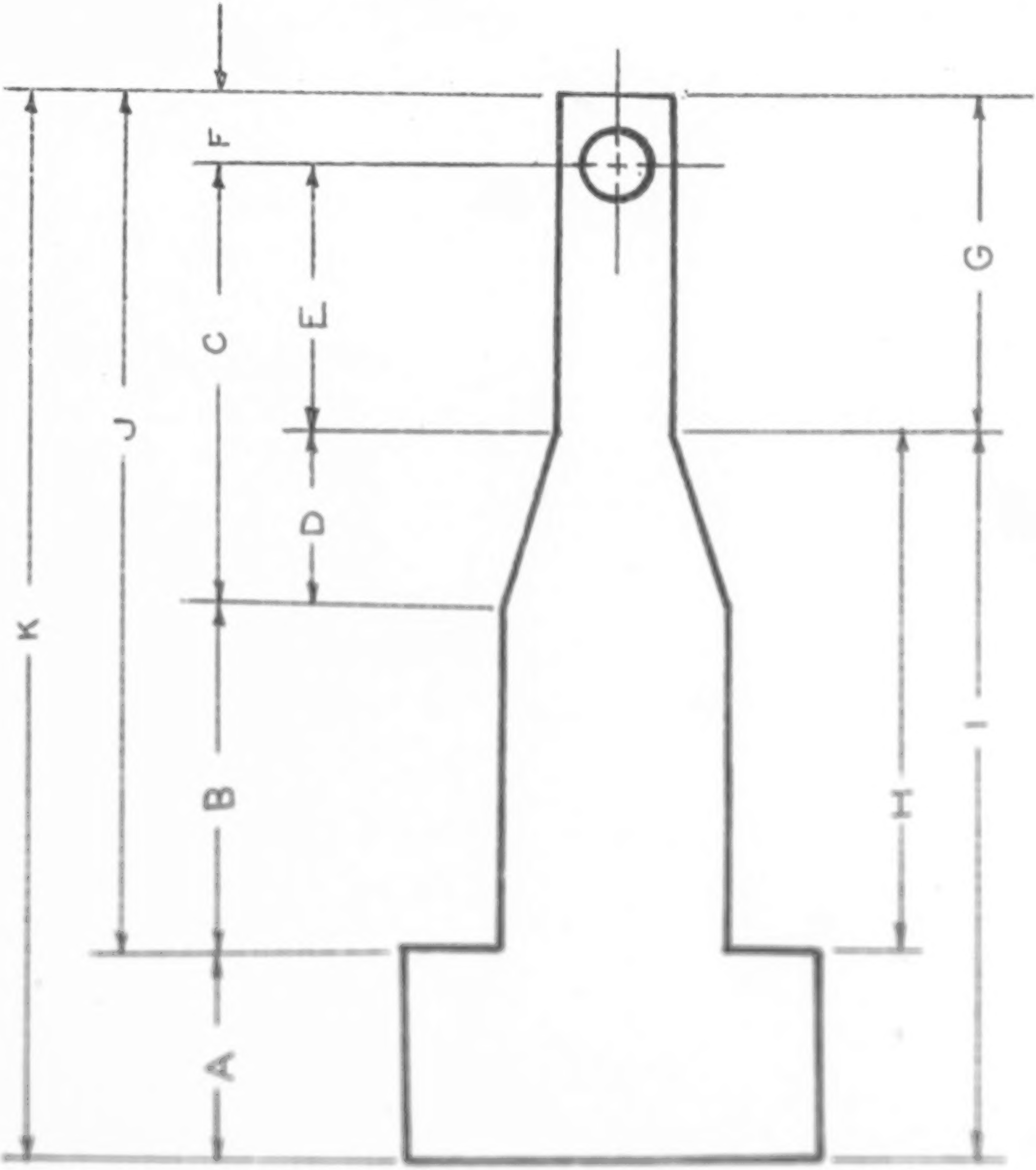
DRAWING NUMBER 1


A
B
G
F
E
D
C
I
H
J

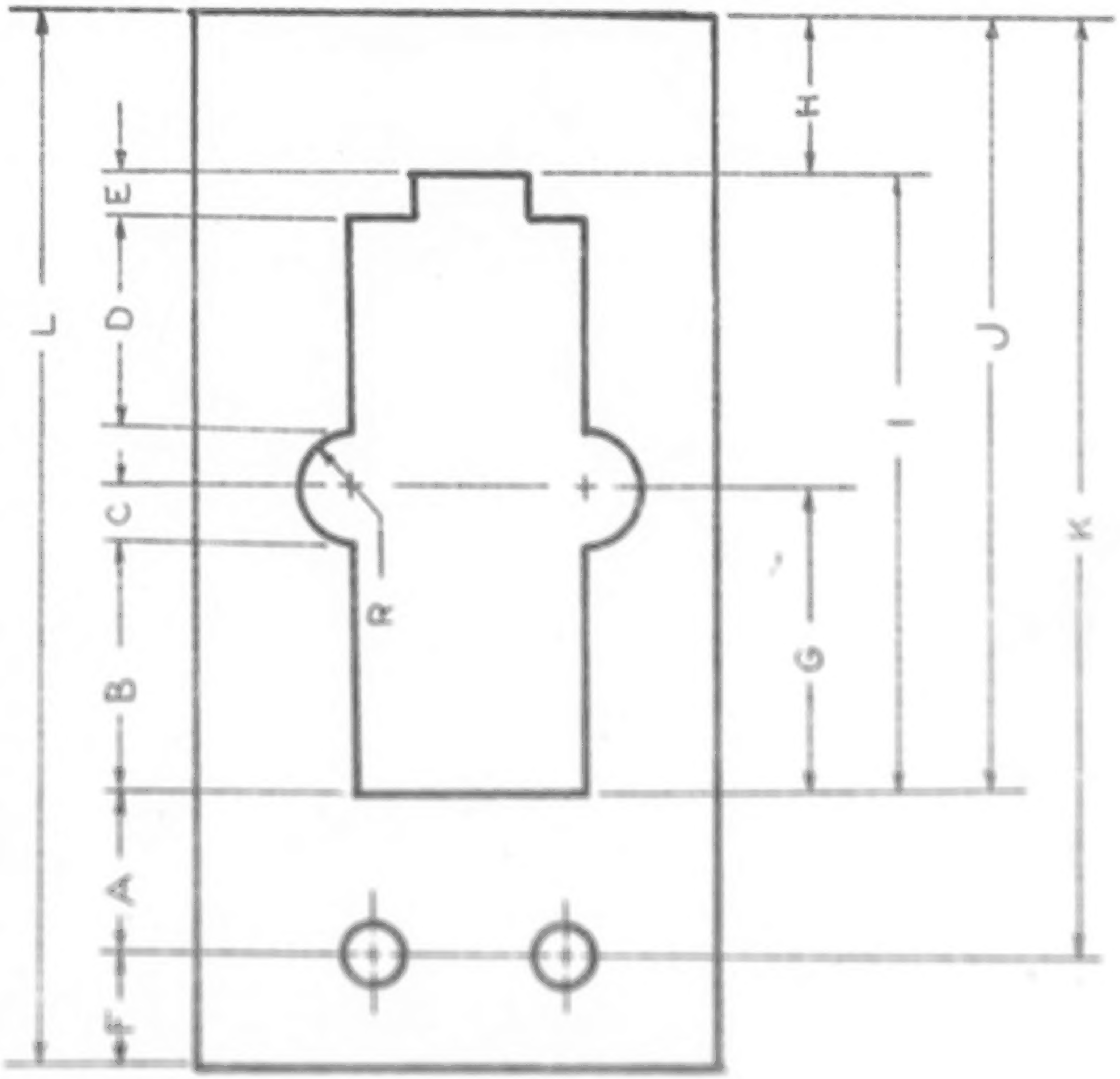
DRAWING NUMBER 2


J
G
I
E
D
C
B
A
F
H

DRAWING NUMBER 3


K
J
F
C
B
A
E
D
G
I
H

DRAWING NUMBER 4


H
E
L
D
J
I
C
K
R
G
B
A
F

DRAWING NO. 1

WHOLE NUMBERS

To Be Put On Drawing

Set I	Set II	Set III	Set IV
C = 46	A = 55	B = 61	A = 69
D = 25	B = 41	C = 24	B = 51
E = 29	D = 12	G = 22	D = 15
F = 42	E = 13	H = 42	H = 35
G = 44	I = 42	J = 104	J = 88

To Find: Answers Given Below

Set I	Set II	Set III	Set IV
A = 142	C = 16	A = 82	C = 20
B = 100	F = 14	D = 18	E = 16
H = 71	G = 15	E = 19	F = 18
I = 115	H = 28	F = 21	G = 19
J = 186	J = 70	I = 62	I = 53

DRAWING NO. 1

FRACTIONS

To Be Put On Drawing

Set I		Set II	
Example 1	**Example 2**	**Example 1**	**Example 2**
$C = 2\frac{7}{8}$	$C = 7\frac{13}{16}$	$A = 16\frac{5}{16}$	$A = 32\frac{1}{2}$
$D = \frac{15}{16}$	$D = 5\frac{27}{32}$	$B = 12$	$B = 25\frac{3}{8}$
$E = 1\frac{3}{16}$	$E = 6\frac{15}{16}$	$D = 3\frac{9}{16}$	$D = 6\frac{29}{32}$
$F = 2\frac{5}{8}$	$F = 7\frac{3}{16}$	$E = 3\frac{3}{4}$	$E = 7\frac{11}{16}$
$G = 2\frac{3}{4}$	$G = 7\frac{19}{32}$	$I = 12\frac{9}{16}$	$I = 22\frac{15}{16}$

To Find: Answers Given Below

Set I		Set II	
Example 1	**Example 2**	**Example 1**	**Example 2**
$A = 7\frac{5}{8}$	$A = 27\frac{5}{16}$	$C = 4\frac{11}{16}$	$C = 10\frac{25}{32}$
$B = 5$	$B = 20\frac{1}{8}$	$F = 4\frac{5}{16}$	$F = 7\frac{1}{8}$
$H = 3\frac{13}{16}$	$H = 13\frac{21}{32}$	$G = 4\frac{1}{2}$	$G = 8\frac{1}{8}$
$I = 6\frac{9}{16}$	$I = 21\frac{1}{4}$	$H = 8\frac{1}{4}$	$H = 17\frac{11}{16}$
$J = 10\frac{3}{8}$	$J = 34\frac{29}{32}$	$J = 20\frac{13}{16}$	$J = 40\frac{5}{8}$

DRAWING NO. 1

FRACTIONS

To Be Put On Drawing

Set III		Set IV	
Example 1	Example 2	Example 1	Example 2
$B = 38\frac{1}{8}$	$B = 25\frac{5}{8}$	$A = 71\frac{3}{32}$	$A = 62\frac{5}{8}$
$C = 15\frac{25}{32}$	$C = 9\frac{27}{32}$	$B = 50\frac{5}{16}$	$B = 46\frac{1}{4}$
$G = 13\frac{3}{4}$	$G = 9\frac{13}{32}$	$D = 12\frac{3}{8}$	$D = 14\frac{9}{32}$
$H = 26\frac{1}{4}$	$H = 17\frac{1}{2}$	$H = 35\frac{3}{4}$	$H = 30\frac{13}{16}$
$J = 65\frac{23}{32}$	$J = 43\frac{3}{4}$	$J = 93\frac{17}{32}$	$J = 79\frac{15}{32}$

To Find: Answers Given Below

Set III		Set IV	
Example 1	Example 2	Example 1	Example 2
$A = 51\frac{31}{32}$	$A = 34\frac{11}{32}$	$C = 23\frac{3}{8}$	$C = 16\frac{17}{32}$
$D = 10\frac{15}{32}$	$D = 7\frac{21}{32}$	$E = 14\frac{9}{16}$	$E = 15\frac{7}{16}$
$E = 11\frac{7}{8}$	$E = 8\frac{1}{8}$	$F = 20\frac{25}{32}$	$F = 16\frac{3}{8}$
$F = 13\frac{27}{32}$	$F = 8\frac{23}{32}$	$G = 22\frac{7}{16}$	$G = 16\frac{27}{32}$
$I = 39\frac{15}{32}$	$I = 26\frac{1}{4}$	$I = 57\frac{25}{32}$	$I = 48\frac{21}{32}$

DRAWING NO. 1

DECIMALS

To Be Put On Drawing

Set I		Set II	
Example 1	Example 2	Example 1	Example 2
C = 4.792	C = 20.084	A = 34.496	A = 98.465
D = 4.273	D = 14.946	B = 24.368	B = 70.856
E = 3.835	E = 16.231	D = 7.514	D = 18.978
F = 4.625	F = 17.896	E = 8.096	E = 21.324
G = 4.487	G = 19.376	I = 25.645	I = 78.000

To Find: Answers Given Below

Set I		Set II	
Example 1	Example 2	Example 1	Example 2
A = 17.525	A = 69.157	C = 8.758	C = 30.554
B = 12.900	B = 51.261	F = 10.128	F = 27.609
H = 9.065	H = 35.030	G = 33.159	G = 96.978
I = 12.947	I = 53.503	H = 16.272	H = 49.532
J = 22.012	J = 88.533	J = 41.917	J = 127.532

DRAWING NO. 1

DECIMALS

To Be Put On Drawing

Set III		Set IV	
Example 1	Example 2	Example 1	Example 2
B = 32.594	B = 20.658	A = 75.476	A = 41.908
C = 12.624	C = 7.846	B = 56.532	B = 31.367
G = 12.480	G = 7.465	D = 17.605	D = 9.265
H = 22.356	H = 13.750	H = 38.092	H = 21.074
J = 56.086	J = 34.932	J = 96.318	J = 53.412

To Find: Answers Given Below

Set III		Set IV	
Example 1	Example 2	Example 1	Example 2
A = 43.606	A = 27.467	C = 20.487	C = 11.809
D = 9.732	D = 5.904	E = 18.440	E = 10.293
E = 10.238	E = 6.908	F = 18.944	F = 10.541
F = 11.012	F = 6.809	G = 20.842	G = 11.504
I = 33.730	I = 21.182	I = 58.226	I = 32.338

DRAWING NO. 1

FRACTION-DECIMAL COMBINATIONS

To Be Put On Drawing

Set I		Set II	
Example 1	Example 2	Example 1	Example 2
C = $12\frac{1}{2}$	C = $24\frac{7}{8}$	A = $23\frac{3}{8}$	A = $66\frac{7}{8}$
D = 3.750	D = 18.750	B = 15.500	B = 47.625
E = $4\frac{7}{8}$	E = $19\frac{3}{4}$	D = 3.750	D = 13.500
F = 10.625	F = $21\frac{5}{8}$	E = $4\frac{7}{8}$	E = $14\frac{3}{4}$
G = $11\frac{3}{8}$	G = 22.250	I = $19\frac{3}{4}$	I = 52.125

To Find: Answers Given Below

Set I		Set II	
Example 1	Example 2	Example 1	Example 2
A = $31\frac{3}{4}$	A = 85.000	C = $6\frac{7}{8}$	C = $19\frac{3}{8}$
B = $21\frac{1}{8}$	B = $63\frac{3}{8}$	F = $7\frac{7}{8}$	F = $19\frac{1}{4}$
H = $16\frac{1}{4}$	H = $43\frac{5}{8}$	G = 7.000	G = $18\frac{1}{8}$
I = $26\frac{7}{8}$	I = $63\frac{5}{8}$	H = $10\frac{5}{8}$	H = $32\frac{7}{8}$
J = $43\frac{1}{8}$	J = $107\frac{1}{4}$	J = $30\frac{3}{8}$	J = 85.000

NOTE: Decimal equivalents for fractions are also acceptable for answers.

DRAWING NO. 1

FRACTION-DECIMAL COMBINATIONS

To Be Put On Drawing

Set III		Set IV	
Example 1	**Example 2**	**Example 1**	**Example 2**
B = 84.625	B = 40.125	A = $87\frac{3}{8}$	A = 76.250
C = 25.750	C = 15.250	B = 64.750	B = $55\frac{7}{8}$
G = $32\frac{7}{8}$	G = $15\frac{3}{4}$	D = 19.125	D = $16\frac{3}{4}$
H = $57\frac{1}{8}$	H = $27\frac{1}{2}$	H = $44\frac{1}{4}$	H = 38.500
J = $146\frac{1}{4}$	J = $69\frac{3}{8}$	J = 111.625	J = $98\frac{1}{8}$

To Find: Answers Given Below

Set III		Set IV	
Example 1	**Example 2**	**Example 1**	**Example 2**
A = $113\frac{3}{8}$	A = $53\frac{5}{8}$	C = $25\frac{1}{8}$	C = $21\frac{3}{4}$
D = $31\frac{3}{8}$	D = $12\frac{1}{4}$	E = $20\frac{1}{2}$	E = $17\frac{3}{8}$
E = $27\frac{1}{2}$	E = $12\frac{5}{8}$	F = $22\frac{5}{8}$	F = $20\frac{5}{8}$
F = $28\frac{3}{4}$	F = $13\frac{1}{2}$	G = $24\frac{1}{4}$	G = $21\frac{7}{8}$
I = $89\frac{1}{8}$	I = $41\frac{7}{8}$	I = $67\frac{3}{8}$	I = $59\frac{5}{8}$

NOTE: Decimal equivalents for fractions are also acceptable for answers.

DRAWING NO. 2

WHOLE NUMBERS

To Be Put on Drawing

Set I	Set II	Set III	Set IV
A = 8	A = 31	A = 25	B = 18
B = 9	G = 112	D = 35	C = 10
C = 5	H = 87	E = 39	F = 34
D = 11	I = 64	G = 90	I = 32
E = 12	J = 179	H = 70	J = 90

To Find: Answers Given Below

Set I	Set II	Set III	Set IV
F = 17	B = 36	B = 29	A = 16
G = 28	C = 20	C = 16	D = 22
H = 22	D = 44	F = 54	E = 24
I = 16	E = 48	I = 51	G = 56
J = 45	F = 67	J = 144	H = 44

DRAWING NO. 2

FRACTIONS

To Be Put On Drawing

Set I		Set II	
Example 1	Example 2	Example 1	Example 2
A = $6\frac{3}{8}$	A = $28\frac{17}{32}$	A = $26\frac{9}{16}$	A = $43\frac{11}{16}$
B = $7\frac{5}{32}$	B = $32\frac{31}{32}$	G = $95\frac{1}{2}$	G = $156\frac{3}{8}$
C = $3\frac{29}{32}$	C = $18\frac{3}{8}$	H = $74\frac{1}{4}$	H = $122\frac{29}{32}$
D = $8\frac{27}{32}$	D = $39\frac{3}{4}$	I = $53\frac{3}{16}$	I = $90\frac{23}{32}$
E = $9\frac{1}{2}$	E = $43\frac{11}{16}$	J = $152\frac{25}{32}$	J = $251\frac{7}{8}$

To Find: Answers Given Below

Set I		Set II	
Example 1	Example 2	Example 1	Example 2
F = $13\frac{17}{32}$	F = $61\frac{1}{2}$	B = $30\frac{23}{32}$	B = $51\frac{13}{16}$
G = $22\frac{1}{4}$	G = $101\frac{13}{16}$	C = $16\frac{31}{32}$	C = $27\frac{13}{32}$
H = $17\frac{7}{16}$	H = $79\frac{7}{8}$	D = $36\frac{7}{32}$	D = $63\frac{5}{16}$
I = $12\frac{3}{4}$	I = $58\frac{1}{8}$	E = $42\frac{5}{16}$	E = $65\frac{21}{32}$
J = $35\frac{25}{32}$	J = $163\frac{5}{16}$	F = $57\frac{9}{32}$	F = $95\frac{1}{2}$

DRAWING NO. 2

FRACTIONS

To Be Put On Drawing

Set III		Set IV	
Example 1	**Example 2**	**Example 1**	**Example 2**
$A = 62\frac{27}{32}$	$A = 29\frac{1}{2}$	$B = 62\frac{11}{16}$	$B = 51\frac{25}{32}$
$D = 88\frac{17}{32}$	$D = 40\frac{5}{8}$	$C = 34\frac{25}{32}$	$C = 29\frac{7}{8}$
$E = 96\frac{19}{32}$	$E = 44\frac{13}{16}$	$F = 112$	$F = 96\frac{3}{4}$
$G = 224\frac{1}{2}$	$G = 104\frac{5}{32}$	$I = 107\frac{5}{8}$	$I = 92$
$H = 174\frac{11}{16}$	$H = 81\frac{15}{32}$	$J = 305\frac{1}{2}$	$J = 258$

To Find: Answers Given Below

Set III		Set IV	
Example 1	**Example 2**	**Example 1**	**Example 2**
$B = 72\frac{15}{32}$	$B = 33\frac{1}{4}$	$A = 49\frac{5}{16}$	$A = 44\frac{31}{32}$
$C = 39\frac{3}{8}$	$C = 18\frac{23}{32}$	$D = 72\frac{27}{32}$	$D = 62\frac{1}{8}$
$F = 135\frac{5}{16}$	$F = 62\frac{3}{4}$	$E = 85\frac{7}{8}$	$E = 69\frac{1}{4}$
$I = 127\frac{29}{32}$	$I = 59\frac{11}{32}$	$G = 193\frac{1}{2}$	$G = 161\frac{1}{4}$
$J = 359\frac{13}{16}$	$J = 166\frac{29}{32}$	$H = 146\frac{25}{32}$	$H = 126\frac{5}{8}$

DRAWING NO. 2

DECIMALS

To Be Put On Drawing

Set I		Set II	
Example 1	Example 2	Example 1	Example 2
A = 18.768	A = 56.215	A = 50.434	A = 12.268
B = 22.607	B = 65.439	G = 180.186	G = 42.895
C = 12.730	C = 36.306	H = 140.673	H = 33.000
D = 27.824	D = 79.817	I = 101.842	I = 24.472
E = 30.432	E = 86.792	J = 288.705	J = 67.907

To Find: Answers Given Below

Set I		Set II	
Example 1	Example 2	Example 1	Example 2
F = 41.375	F = 121.654	B = 58.085	B = 12.744
G = 70.986	G = 202.915	C = 32.154	C = 7.988
H = 54.105	H = 157.950	D = 69.688	D = 16.484
I = 40.554	I = 116.123	E = 78.344	E = 18.423
J = 112.361	J = 324.569	F = 108.519	F = 25.012

DRAWING NO. 2

DECIMALS

To Be Put On Drawing

Set III		Set IV	
Example 1	Example 2	Example 1	Example 2
A = 11.588	A = 28.684	B = 27.342	B = 16.245
D = 15.764	D = 39.506	C = 14.800	C = 8.894
E = 16.218	E = 44.437	F = 51.240	F = 30.708
G = 39.376	G = 101.250	I = 48.756	I = 28.750
H = 30.890	H = 78.717	J = 137.285	J = 81.500

To Find: Answers Given Below

Set III		Set IV	
Example 1	Example 2	Example 1	Example 2
B = 11.908	B = 32.726	A = 23.898	A = 14.463
C = 7.394	C = 17.307	D = 33.956	D = 19.856
F = 23.496	F = 61.410	E = 37.289	E = 22.042
I = 23.158	I = 56.813	G = 86.045	G = 50.792
J = 62.872	J = 162.660	H = 66.040	H = 39.602

DRAWING NO. 2

FRACTION-DECIMAL COMBINATIONS

To Be Put On Drawing

Set I		Set II	
Example 1	**Example 2**	**Example 1**	**Example 2**
A = 16.500	A = 43.625	A = 7.500	A = $37\frac{3}{8}$
B = $19\frac{7}{8}$	B = $50\frac{1}{2}$	G = 25.125	G = 135.000
C = $10\frac{1}{4}$	C = $28\frac{3}{4}$	H = $19\frac{3}{4}$	H = $105\frac{1}{8}$
D = $22\frac{5}{8}$	D = 62.500	I = $14\frac{3}{8}$	I = $76\frac{5}{8}$
E = 21.125	E = $66\frac{7}{8}$	J = $40\frac{1}{2}$	J = 216.250

To Find: Answers Given Below

Set I		Set II	
Example 1	**Example 2**	**Example 1**	**Example 2**
F = $36\frac{3}{8}$	F = $94\frac{1}{8}$	B = $7\frac{7}{8}$	B = $43\frac{7}{8}$
G = 54.000	G = $158\frac{1}{8}$	C = $4\frac{3}{8}$	C = $23\frac{7}{8}$
H = $46\frac{5}{8}$	H = $122\frac{7}{8}$	D = 10.000	D = $52\frac{3}{4}$
I = $32\frac{7}{8}$	I = $91\frac{1}{4}$	E = $10\frac{3}{4}$	E = $58\frac{3}{8}$
J = $90\frac{3}{8}$	J = $252\frac{1}{4}$	F = $15\frac{3}{8}$	F = $81\frac{1}{4}$

NOTE: Decimal equivalents for fractions are also acceptable for answers.

DRAWING NO. 2

FRACTION-DECIMAL COMBINATIONS

To Be Put On Drawing

Set III		Set IV	
Example 1	Example 2	Example 1	Example 68
A = 18.250	A = $31\frac{1}{2}$	B = $30\frac{7}{8}$	B = $24\frac{1}{4}$
D = $29\frac{3}{4}$	D = 43.375	C = $17\frac{1}{4}$	C = $11\frac{3}{8}$
E = 32.125	E = $48\frac{7}{8}$	F = 57.000	F = 45.125
G = $77\frac{5}{8}$	G = 112.000	I = 53.625	I = 43.250
H = $55\frac{3}{8}$	H = $87\frac{3}{4}$	J = $152\frac{3}{4}$	J = $118\frac{1}{8}$

To Find: Answers Given Below

Set III		Set IV	
Example 1	Example 2	Example 1	Example 2
B = $21\frac{3}{8}$	B = $36\frac{1}{2}$	A = $26\frac{1}{8}$	A = $20\frac{7}{8}$
C = $15\frac{3}{4}$	C = $19\frac{3}{4}$	D = $36\frac{3}{8}$	D = $31\frac{7}{8}$
F = $39\frac{5}{8}$	F = 68.000	E = $42\frac{1}{8}$	E = $29\frac{3}{4}$
I = $45\frac{1}{2}$	I = $63\frac{1}{8}$	G = $95\frac{3}{4}$	G = 73
J = $117\frac{1}{4}$	J = 180.000	H = $74\frac{1}{4}$	H = $56\frac{1}{2}$

NOTE: Decimal equivalents for fractions are also acceptable for answers.

DRAWING NO. 3

WHOLE NUMBERS

To Be Put On Drawing

Set 1	Set 2	Set 3	Set 4
A = 23	C = 13	B = 28	A = 19
B = 38	F = 2	C = 34	D = 16
D = 16	H = 16	G = 26	E = 26
E = 25	J = 26	H = 41	I = 71
F = 6	K = 32	I = 57	J = 85

To Find: Answers Given Below

Set 1	Set 2	Set 3	Set 4
C = 41	A = 6	A = 16	B = 36
G = 31	B = 11	D = 13	C = 42
H = 54	D = 5	E = 21	F = 7
I = 77	E = 8	F = 5	G = 33
J = 85	G = 10	J = 67	H = 52
K = 108	I = 22	K = 83	K = 104

DRAWING NO. 3

FRACTIONS

To Be Put On Drawing

Set I		Set II	
Example 1	**Example 2**	**Example 1**	**Example 2**
A = $8\frac{1}{8}$	A = $7\frac{5}{16}$	C = $30\frac{15}{16}$	C = $8\frac{9}{16}$
B = $13\frac{13}{16}$	B = $12\frac{21}{32}$	F = $4\frac{1}{2}$	F = $1\frac{9}{32}$
D = $6\frac{1}{2}$	D = $5\frac{29}{32}$	H = $37\frac{1}{8}$	H = $10\frac{5}{32}$
E = $10\frac{5}{8}$	E = $9\frac{9}{16}$	J = $60\frac{3}{4}$	J = $16\frac{3}{4}$
F = $2\frac{9}{16}$	F = $2\frac{1}{4}$	K = $75\frac{3}{8}$	K = $20\frac{13}{16}$

To Find: Answers Given Below

Set I		Set II	
Example 1	**Example 2**	**Example 1**	**Example 2**
C = $17\frac{1}{8}$	C = $15\frac{15}{32}$	A = $14\frac{5}{8}$	A = $4\frac{1}{16}$
G = $13\frac{3}{16}$	G = $11\frac{13}{16}$	B = $25\frac{5}{16}$	B = $6\frac{29}{32}$
H = $20\frac{5}{16}$	H = $18\frac{9}{16}$	D = $11\frac{13}{16}$	D = $3\frac{1}{4}$
I = $28\frac{7}{16}$	I = $25\frac{7}{8}$	E = $19\frac{1}{8}$	E = $5\frac{5}{16}$
J = $33\frac{1}{2}$	J = $30\frac{3}{8}$	G = $23\frac{5}{8}$	G = $6\frac{19}{32}$
K = $41\frac{5}{8}$	K = $37\frac{11}{16}$	I = $51\frac{3}{4}$	I = $14\frac{7}{32}$

DRAWING NO. 3

FRACTIONS

To Be Put On Drawing

Set III		Set IV	
Example 1	**Example 2**	**Example 1**	**Example 2**
B = $19\frac{5}{16}$	B = $26\frac{15}{32}$	A = $10\frac{1}{16}$	A = $5\frac{1}{32}$
C = $23\frac{5}{8}$	C = $32\frac{19}{32}$	D = 7	D = $3\frac{1}{2}$
G = $18\frac{3}{16}$	G = 25	E = $10\frac{15}{16}$	E = $5\frac{15}{32}$
H = $28\frac{5}{16}$	H = $38\frac{7}{8}$	I = $33\frac{11}{16}$	I = $16\frac{27}{32}$
I = $39\frac{7}{16}$	I = $54\frac{5}{16}$	J = $37\frac{3}{16}$	J = $18\frac{19}{32}$

To Find: Answers Given Below

Set III		Set IV	
Example 1	**Example 2**	**Example 1**	**Example 2**
A = $11\frac{1}{8}$	A = $15\frac{7}{16}$	B = $16\frac{5}{8}$	B = $8\frac{5}{16}$
D = 9	D = $12\frac{13}{32}$	C = $17\frac{15}{16}$	C = $8\frac{31}{32}$
E = $14\frac{5}{8}$	E = $20\frac{3}{16}$	F = $2\frac{5}{8}$	F = $1\frac{5}{16}$
F = $3\frac{9}{16}$	F = $4\frac{13}{16}$	G = $13\frac{9}{16}$	G = $6\frac{25}{32}$
J = $46\frac{1}{2}$	J = $63\frac{7}{8}$	H = $23\frac{5}{8}$	H = $11\frac{13}{16}$
K = $57\frac{5}{8}$	K = $79\frac{5}{16}$	K = $47\frac{1}{4}$	K = $23\frac{5}{8}$

DRAWING NO. 3

DECIMALS

To Be Put On Drawing

Set I		Set II	
Example 1	**Example 2**	**Example 1**	**Example 2**
A = 13.392	A = 16.187	C = 9.004	C = 18.012
B = 22.508	B = 27.628	F = 1.313	F = 2.461
D = 10.723	D = 14.096	H = 11.848	H = 23.604
E = 17.075	E = 21.254	J = 18.629	J = 37.041
F = 3.964	F = 5.040	K = 23.674	K = 47.206

To Find: Answers Given Below

Set I		Set II	
Example 1	**Example 2**	**Example 1**	**Example 2**
C = 27.798	C = 35.350	A = 5.045	A = 10.165
G = 21.039	G = 26.294	B = 8.312	B = 16.568
H = 33.231	H = 41.724	D = 3.536	D = 7.036
I = 46.623	I = 57.911	E = 5.468	E = 10.976
J = 54.270	J = 68.018	G = 6.781	G = 13.437
K = 67.662	K = 84.205	I = 16.893	I = 33.769

DRAWING NO. 3

DECIMALS

To Be Put On Drawing

Set III		Set IV	
Example 1	Example 2	Example 1	Example 2
B = 2.063	B = 4.124	A = 19.145	A = 6.318
C = 2.437	C = 5.118	D = 16.206	D = 4.604
G = 1.875	G = 3.758	E = 25.918	E = 8.458
H = 3.000	H = 6.074	I = 71.025	I = 22.020
I = 4.125	I = 8.320	J = 85.633	J = 26.048

To Find: Answers Given Below

Set III		Set IV	
Example 1	Example 2	Example 1	Example 2
A = 1.125	A = 2.246	B = 35.674	B = 11.098
D = .937	D = 1.950	C = 42.124	C = 13.062
E = 1.500	E = 3.168	F = 7.835	F = 1.888
F = .375	F = .590	G = 33.753	G = 10.346
J = 4.875	J = 9.832	H = 51.880	H = 15.702
K = 6.000	K = 12.078	K = 104.778	K = 32.366

DRAWING NO. 3

FRACTION-DECIMAL COMBINATIONS

To Be Put On Drawing

Set I		Set II	
Example 1	**Example 2**	**Example 1**	**Example 2**
A = 11.875	A = 19.125	C = $2\frac{3}{4}$	C = $32\frac{1}{8}$
B = $22\frac{1}{2}$	B = $35\frac{7}{8}$	F = .875	F = 7.500
D = 10.000	D = 16.750	H = $3\frac{1}{8}$	H = $41\frac{1}{8}$
E = $16\frac{1}{4}$	E = $26\frac{3}{8}$	J = 5.500	J = 69.875
F = $4\frac{3}{8}$	F = $7\frac{1}{4}$	K = $6\frac{5}{8}$	K = $86\frac{3}{8}$

To Find: Answers Given Below

Set I		Set II	
Example 1	**Example 2**	**Example 1**	**Example 2**
C = $26\frac{1}{4}$	C = $43\frac{1}{8}$	A = $1\frac{1}{8}$	A = $16\frac{1}{2}$
G = $20\frac{5}{8}$	G = $33\frac{5}{8}$	B = $1\frac{7}{8}$	B = $30\frac{1}{4}$
H = $32\frac{1}{2}$	H = $52\frac{5}{8}$	D = $1\frac{1}{4}$	D = $10\frac{7}{8}$
I = $44\frac{3}{8}$	I = $71\frac{3}{4}$	E = $1\frac{1}{2}$	E = $21\frac{1}{4}$
J = $53\frac{1}{8}$	J = $86\frac{1}{4}$	G = $2\frac{3}{8}$	G = $28\frac{3}{4}$
K = 65	K = $105\frac{3}{8}$	I = $4\frac{1}{4}$	I = $57\frac{5}{8}$

NOTE: Decimal equivalents for fractions are also acceptable for answers.

DRAWING NO. 3

FRACTION-DECIMAL COMBINATIONS

To Be Put On Drawing

Set III		Set IV	
Example 1	**Example 2**	**Example 1**	**Example 2**
$B = 12\frac{3}{8}$	$B = 5\frac{3}{4}$	$A = 4.500$	$A = 22.875$
$C = 14.625$	$C = 6.875$	$D = 4.750$	$D = 16.000$
$G = 11\frac{1}{4}$	$G = 5\frac{1}{4}$	$E = 6\frac{7}{8}$	$E = 25\frac{1}{4}$
$H = 18.000$	$H = 8.500$	$I = 18\frac{1}{2}$	$I = 77\frac{1}{4}$
$I = 24\frac{3}{4}$	$I = 11\frac{3}{8}$	$J = 22\frac{5}{8}$	$J = 85\frac{3}{4}$

To Find: Answers Given Below

Set III		Set IV	
Example 1	**Example 2**	**Example 1**	**Example 2**
$A = 6\frac{3}{4}$	$A = 2\frac{7}{8}$	$B = 9\frac{1}{4}$	$B = 38\frac{3}{8}$
$D = 5\frac{5}{8}$	$D = 2\frac{3}{4}$	$C = 11\frac{5}{8}$	$C = 41\frac{1}{4}$
$E = 9.000$	$E = 4\frac{1}{8}$	$F = 1\frac{3}{4}$	$F = 6\frac{1}{8}$
$F = 2\frac{1}{4}$	$F = 1\frac{1}{8}$	$G = 8\frac{5}{8}$	$G = 31\frac{3}{8}$
$J = 29\frac{1}{4}$	$J = 13\frac{3}{4}$	$H = 14.000$	$H = 54\frac{3}{8}$
$K = 36.000$	$K = 16\frac{5}{8}$	$K = 27\frac{1}{8}$	$K = 108\frac{5}{8}$

NOTE: Decimal equivalents for fractions are also acceptable for answers.

DRAWING NO. 4

WHOLE NUMBERS

To Be Put On Drawing

Set 1	Set 2	Set 3	Set 4
A = 21	E = 4	A = 32	C = 3
B = 28	F = 12	B = 42	D = 11
C = 7	G = 44	D = 33	F = 5
D = 22	I = 85	H = 19	G = 18
E = 31	J = 102	K = 153	I = 34
F = 9	L = 141	L = 166	J = 41
H = 13	R = 9	R = 11	K = 51

To Find: Answers Given Below

Set 1	Set 2	Set 3	Set 4
G = 35	A = 27	C = 11	A = 10
I = 67	B = 35	E = 5	B = 15
J = 80	C = 9	F = 13	E = 2
K = 101	D = 28	G = 53	H = 7
L = 110	H = 17	I = 102	L = 56
R = 7	K = 129	J = 121	R = 3

DRAWING NO. 4

FRACTIONS

To Be Put On Drawing

Set I		Set II	
Example 1	**Example 2**	**Example 1**	**Example 2**
$A = 2\frac{1}{8}$	$A = 32\frac{5}{8}$	$E = \frac{3}{16}$	$E = 1\frac{1}{4}$
$B = 3\frac{3}{8}$	$B = 41\frac{1}{2}$	$F = \frac{9}{16}$	$F = 3\frac{3}{4}$
$C = \frac{7}{8}$	$C = 10\frac{3}{4}$	$G = 2\frac{3}{16}$	$G = 15\frac{5}{16}$
$D = 3\frac{1}{4}$	$D = 34$	$I = 4\frac{3}{16}$	$I = 29\frac{3}{16}$
$E = \frac{3}{8}$	$E = 5$	$J = 5$	$J = 34\frac{11}{16}$
$F = 1\frac{3}{4}$	$F = 14\frac{3}{8}$	$L = 6\frac{7}{8}$	$L = 47\frac{13}{16}$
$H = 1\frac{1}{2}$	$H = 31\frac{3}{4}$	$R = \frac{7}{16}$	$R = 3$

To Find: Answers Given Below

Set I		Set II	
Example 1	**Example 2**	**Example 1**	**Example 2**
$G = 4\frac{1}{4}$	$G = 52\frac{1}{4}$	$A = 1\frac{5}{16}$	$A = 9\frac{3}{8}$
$I = 8\frac{3}{4}$	$I = 102$	$B = 1\frac{3}{4}$	$B = 12\frac{5}{16}$
$J = 10\frac{1}{4}$	$J = 133\frac{3}{4}$	$C = \frac{7}{16}$	$C = 3$
$K = 12\frac{3}{8}$	$K = 166\frac{3}{8}$	$D = 1\frac{3}{8}$	$D = 9\frac{5}{8}$
$L = 14\frac{1}{8}$	$L = 180\frac{3}{4}$	$H = \frac{13}{16}$	$H = 5\frac{1}{2}$
$R = \frac{7}{8}$	$R = 10\frac{3}{4}$	$K = 6\frac{5}{16}$	$K = 44\frac{1}{16}$

DRAWING NO. 4

FRACTIONS

To Be Put On Drawing

Set III		Set IV	
Example 1	**Example 2**	**Example 1**	**Example 2**
A = $6\frac{1}{4}$	A = $4\frac{29}{32}$	C = $5\frac{3}{16}$	C = $2\frac{19}{32}$
B = $12\frac{5}{8}$	B = $5\frac{3}{16}$	D = $17\frac{5}{8}$	D = $8\frac{13}{16}$
D = $11\frac{3}{16}$	D = $4\frac{27}{64}$	F = $7\frac{11}{16}$	F = $3\frac{13}{32}$
H = $5\frac{13}{16}$	H = $3\frac{1}{2}$	G = $25\frac{15}{16}$	G = $12\frac{31}{32}$
K = $42\frac{25}{32}$	K = $19\frac{25}{64}$	I = $51\frac{1}{4}$	I = $25\frac{39}{64}$
L = $45\frac{7}{8}$	L = $21\frac{3}{16}$	J = $66\frac{3}{32}$	J = $33\frac{3}{64}$
R = $2\frac{7}{16}$	R = $\frac{3}{8}$	K = $82\frac{5}{16}$	K = $41\frac{15}{32}$

To Find: Answers Given Below

Set III		Set IV	
Example 1	**Example 2**	**Example 1**	**Example 2**
C = $2\frac{7}{16}$	C = $\frac{3}{8}$	A = $16\frac{7}{32}$	A = $8\frac{27}{64}$
E = $2\frac{1}{32}$	E = $\frac{5}{8}$	B = $20\frac{3}{4}$	B = $10\frac{3}{8}$
F = $3\frac{3}{32}$	F = $1\frac{51}{64}$	E = $2\frac{1}{2}$	E = $1\frac{15}{64}$
G = $15\frac{1}{16}$	G = $5\frac{9}{16}$	H = $14\frac{27}{32}$	H = $7\frac{7}{16}$
I = $30\frac{23}{32}$	I = $10\frac{63}{64}$	L = 90	L = $44\frac{7}{8}$
J = $36\frac{17}{32}$	J = $14\frac{31}{64}$	R = $5\frac{3}{16}$	R = $2\frac{19}{32}$

DRAWING NO. 4

DECIMALS

To Be Put On Drawing

Set I		Set II	
Example 1	**Example 2**	**Example 1**	**Example 2**
A = 2.125	A = 32.625	E = .188	E = 1.247
B = 3.375	B = 41.500	F = .563	F = 3.750
C = .875	C = 10.750	G = 2.188	G = 15.294
D = 3.250	D = 34.000	I = 4.189	I = 29.290
E = .625	E = 5.000	J = 5.002	J = 34.774
F = 1.750	F = 14.375	L = 6.878	L = 47.899
H = 1.500	H = 31.750	R = .438	R = 2.986

To Find: Answers Given Below

Set I		Set II	
Example 1	**Example 2**	**Example 1**	**Example 2**
G = 4.250	G = 52.250	A = 1.313	A = 9.375
I = 9.000	I = 102.000	B = 1.750	B = 12.308
J = 10.500	J = 133.750	C = .438	C = 2.986
K = 12.625	K = 166.375	D = 1.375	D = 9.763
L = 14.375	L = 180.750	H = .813	H = 5.484
R = .875	R = 10.750	K = 6.315	K = 44.149

DRAWING NO. 4

DECIMALS

To Be Put On Drawing

Set III		Set IV	
Example 1	**Example 2**	**Example 1**	**Example 2**
A = 6.248	A = 4.906	C = 2.594	C = 5.185
B = 12.625	B = 5.188	D = 8.825	D = 17.624
D = 11.197	D = 4.421	F = 3.408	F = 7.679
H = 5.824	H = 3.496	G = 12.974	G = 25.985
K = 41.926	K = 19.385	I = 25.627	I = 51.302
L = 47.012	L = 21.185	J = 33.063	J = 66.142
R = 2.436	R = .375	K = 41.483	K = 82.362

To Find: Answers Given Below

Set III		Set IV	
Example 1	**Example 2**	**Example 1**	**Example 2**
C = 2.436	C = .375	A = 8.420	A = 16.220
E = 1.160	E = .624	B = 10.380	B = 20.800
F = 5.086	F = 1.800	E = 1.234	E = 2.508
G = 15.061	G = 5.563	H = 7.436	H = 14.840
I = 29.854	I = 10.983	L = 44.891	L = 90.041
J = 35.678	J = 14.479	R = 2.594	R = 5.185

DRAWING NO. 4

FRACTION-DECIMAL COMBINATIONS

To Be Put On Drawing

Set I		Set II	
Example 1	**Example 2**	**Example 1**	**Example 2**
A = 1.875	$A = 30\frac{5}{8}$	$E = \frac{1}{4}$	$E = 1\frac{1}{8}$
$B = 2\frac{3}{8}$	B = 39.500	$F = \frac{1}{2}$	$F = 2\frac{3}{4}$
C = .750	$C = 8\frac{3}{4}$	$G = 2\frac{1}{8}$	$G = 9\frac{3}{8}$
$D = 2\frac{1}{4}$	D = 32.000	$I = 4\frac{1}{8}$	$I = 23\frac{1}{4}$
$E = \frac{1}{2}$	E = 3.125	J = 5.125	J = 28.750
F = 1.625	$F = 12\frac{3}{8}$	L = 6.875	L = 41.750
$H = 1\frac{1}{8}$	$H = 29\frac{3}{4}$	R = .500	R = 2.500

To Find: Answers Given Below

Set I		Set II	
Example 1	**Example 2**	**Example 1**	**Example 2**
$G = 3\frac{1}{8}$	$G = 48\frac{1}{4}$	$A = 1\frac{1}{4}$	$A = 10\frac{1}{4}$
$I = 6\frac{5}{8}$	$I = 92\frac{1}{8}$	$B = 1\frac{5}{8}$	$B = 6\frac{7}{8}$
$J = 7\frac{3}{4}$	$J = 121\frac{7}{8}$	$C = \frac{1}{2}$	$C = 2\frac{1}{2}$
$K = 9\frac{5}{8}$	$K = 152\frac{1}{2}$	$D = 1\frac{1}{4}$	$D = 10\frac{1}{4}$
$L = 11\frac{1}{4}$	$L = 164\frac{7}{8}$	H = 1.000	$H = 5\frac{1}{2}$
$R = \frac{3}{4}$	$R = 8\frac{3}{4}$	$K = 6\frac{3}{8}$	K = 39.000

NOTE: Decimal equivalents for fractions are also acceptable for answers.

DRAWING NO. 4

FRACTION-DECIMAL COMBINATIONS

To Be Put On Drawing

Set III		Set IV	
Example 1	**Example 2**	**Example 1**	**Example 2**
A = $4\frac{1}{4}$	A = $3\frac{3}{4}$	C = $1\frac{1}{4}$	C = $3\frac{7}{8}$
B = $7\frac{3}{4}$	B = $4\frac{7}{8}$	D = $7\frac{1}{8}$	D = $16\frac{3}{8}$
D = $10\frac{3}{8}$	D = $4\frac{1}{2}$	F = $6\frac{7}{8}$	F = $13\frac{5}{8}$
H = $5\frac{3}{4}$	H = $3\frac{1}{2}$	G = 8.250	G = 18.750
K = 36.000	K = 18.375	I = 18.875	I = 42.750
L = 42.750	L = 20.000	J = $22\frac{3}{4}$	J = $54\frac{1}{2}$
R = 2.125	R = .375	K = 30.000	K = 72.375

To Find: Answers Given Below

Set III		Set IV	
Example 1	**Example 2**	**Example 1**	**Example 2**
C = $2\frac{1}{8}$	C = $\frac{3}{8}$	A = $7\frac{1}{4}$	A = $17\frac{7}{8}$
E = $3\frac{5}{8}$	E = 1.000	B = 7.000	B = $14\frac{7}{8}$
F = $6\frac{3}{4}$	F = $1\frac{5}{8}$	E = $2\frac{1}{4}$	E = $3\frac{3}{4}$
G = $9\frac{7}{8}$	G = $5\frac{1}{4}$	H = $3\frac{7}{8}$	H = $11\frac{3}{4}$
I = 26.000	I = $11\frac{1}{8}$	L = $36\frac{7}{8}$	L = 86
J = $31\frac{3}{4}$	J = $14\frac{5}{8}$	R = $1\frac{1}{4}$	R = $3\frac{7}{8}$

NOTE: Decimal equivalents for fractions are also acceptable for answers.

VERBAL PROBLEMS

The following 25 problems can be used as drill exercises or homework problems.

1. The suggested spark plug gap for a 1968 Corvair is .030" while the gap for a 1966 Renault is .024". What is the difference in spark plug gaps?

2. A John Deere model 110 garden tractor requires a spark gap of .025" and a 1966 Sunbeam Tiger needs a gap of .030". What is the difference in spark plug gaps?

3. A California refinery can refine up to 165,000 barrels of crude oil per day. If a barrel contains 42 gallons, what is the capacity of this refinery in gallons?

4. When ordering bricks a contractor figures 7 bricks per square foot. About how many bricks are needed for a wall whose area is 1584 square feet?

5. One course of mortared bricks layed flat is 2 -3/4 inches high. How many courses of brick will be required for the side of a building which is 18 feet 4 inches high?

6. Oversized bricks are ordered on the basis of 5 bricks per square foot. About how many bricks will be needed for a wall which is 8 feet high and 28 feet long? What is the cost of the bricks if they sell for $75.00 per thousand?

7. A 5 inch diameter drainage pipe requires a fall of 1/8 inch per foot. How much fall is required for the following lengths:

   a. 60 feet

   b. 110 feet

   c. 200 feet

8. One course of mortared bricks layed flat is 2-5/8 inches high. How high will a wall be if it is 10 courses of brick high?

9. One course of mortared bricks layed flat is 2-5/8 inches high. How many courses of brick will be required for a wall which is 8 feet 9 inches high?

10. When ordering hardwood flooring it is necessary to order 34% more than the actual area. If the area of a floor is 1431 square feet, find the number of square feet of floor that should be ordered.

11. If hardwood flooring costs 60¢ per square foot, find the cost of 3015 square feet of flooring.

12. The first coat of exterior house paint requires 1 gallon per 468 square feet. How many gallons will be required for a house with surface area of 2080 square feet?

13. On the average it requires 1 to 2 hours to overhaul the fuel pump of a 1966 Cadillac. If the labor rate is $6.50 per hour, find the labor charge for this job.

14. It takes about 1.5 hours to remove and replace the generator brushes on a 1967 Corvette. Find the total labor charge if the rate if $7.25 per hour.

15. The inside diameter of a pipe is .599" and the outside diameter is 1.315". Find the wall thickness.

16. In 1930, there were about 15,700 A & P stores. Today there are only about 4,500. Find the percent of decrease.

17. Shingles are often bought by the "square." A square is enough to cover 100 square feet of area. About how many squares will be needed for a roof which covers 1526 square feet?

18. About 2 pounds of 3d nails are needed for each square of roof surface. How many pounds of nails should be ordered for a roof covering 1290 square feet?

19. If 1500 wood laths will cover about 100 square yards of surface, find the number of laths needed for 175 square yards of surface.

20. It takes about $\frac{5}{8}$ of a cubic yard of mortar to lay 1000 bricks with $\frac{1}{2}$" mortar joints. About how many cubic yards will be needed to lay 4500 bricks?

21. A stonemason buys hydrated finishing lime in 50 pound sacks at 60¢ per sack. Find the cost of $\frac{3}{4}$ of a ton of lime.

22. Gravel weighs about 3000 pounds per cubic yard. At the rate of $2.25 per ton, find the cost of 25 cubic yards of gravel.

23. A stonemason purchases a 10" I beam which is 28 feet long. Find the total weight of the beam if it weighs 25.4 pounds per linear foot.

24. A planer changed the thickness of a board from $\frac{7}{8}$" to $\frac{11}{16}$". How much was removed?

25. After cooling, a 20" casting shrinks $\frac{17}{16}$". Find the size when cold.